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EAST AFRICAN AGRICULTURAL RESEARCH STATION, AMANI

ANNUAL REPORT 1938

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Continued on page 3 of cover

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EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

Report for the Period 1st January, 1938, to 31st December, 1938.

STAFF LIST.

Director.—A. G. G. Hill, B.A., B.Agr., A.R.C.Sc.I.

Plant Pathologist.—H. H. Storey, M.A., Ph.D.

Entomologist.—T. W. Kirkpatrick, M.A., Dipl. Agric. (Cantab.), F.R.E.S.

Soil Chemist.—G. Milne, M.Sc., F.I.C.

Biochemist.—R. R. Le G. Worsley, A.R.C.S., B.Sc., Ph.D., D.I.C.

Plant Physiologist.—F. J. Nutman, A.R.C.S., M.Sc., D.I.C.

Plant Physiologist (2).—J. Glover, M.Sc. (Botany).

Plant Geneticist.—L. R. Doughty, B.Sc. (Agric.) N.D.A.

Superintendent of Plantations.—F. M. Rogers.

Secretary and Librarian.—R. E. Moreau, C.M.Z.S., M.B.O.U.

Botanist.—P. J. Greenway, F.L.S.

Assistant Superintendent of Plantations.—C. B. Gibbins.

Assistant Secretary and Librarian.—W. M. Nutter.

Engineer Mechanic.—T. V. Greenwood.

Scientific Assistant (Plant Path.).—R. F. W. Nichols.

Scientific Assistant (Soil Chem.).—W. E. Calton, B.A., Dipl. Agric.

Mr. C. B. Gibbins joined the staff on 27th March, 1938. Commdr. H. V. Low was temporarily employed as Acting Superintendent of Plantations from 18th January to 26th June, 1938.

LEAVE MOVEMENTS.

	Departed. 1938.	*Returned.* 1938.
Mr. F. J. Nutman ...	—	22nd July.
Mr. P. J. Greenway	—	26th June.
Mr. G. Milne	—	14th November.
Mr. F. M. Rogers ...	20th January.	28th October.
Mr. L. R. Doughty ...	3rd April.	28th October.
Mr. W. M. Nutter ...	7th June.	—
Mr. R. F. W. Nichols	26th July.	—

REPORT OF DIRECTOR.

Research.

The record of work during the year 1938 contained in the annexed sectional reports shows that steady progress has been made, although all but two sections are hampered by lack of trained assistants. Apart from European assistants, the almost complete lack of trained African assistants on the staff is, I feel, a weak point in the organisation of the Station. Suitable Africans are extremely difficult to find and usually demand a comparatively high salary.

Considerable progress was again made by the Plant Pathologist with the investigations into the mechanism of transmission of virus diseases by insects. In his report on page 13 Dr. Storey discusses his researches on the manner in which an insect inoculates virus into a plant and on the causes of variations in the ability to infect shown by different individuals of a single species.

In connection with these studies we have been fortunate in obtaining from the Cotton Breeding Station, Barberton, certain inbred, but non-commercial, lines of maize highly resistant to streak disease which may prove of great value to maize breeders in East Africa, where streak disease may be a serious problem for native farmers.

Steady progress has been made with the breeding of cassava types resistant to mosaic disease, over 300 crosses having been made to date between the more resistant types. Interspecific hybrids are of considerable promise.

In connection with a serious outbreak of suspected virus disease in Passion Fruit plantations in Kenya the Plant Pathologist made two special visits to that Colony during the year. This disease in its typical form resembles the disease known in Australia as " Woodiness ". As a result of these visits and in collaboration with Dr. Nattrass, Senior Plant Pathologist, Kenya, a co-operative programme of research into this problem has been drawn up. The most promising line of investigation appears to be the search for resistant strains either from *Passiflora edulis* or from interspecific hybrids. A large collection of Passiflora species is now being made for this purpose but breeding work cannot be expected to yield early results.

In November the Director of Agriculture, Zanzibar, and Dr. Campbell, special research officer, visited Amani, when the whole position in regard to our knowledge of " Sudden Death " of cloves was discussed prior to Dr. Campbell taking up his investigations. Mr. Gibbins, Assistant Superintendent of Plantations, was sent to Zanzibar in November to assist Dr. Campbell with his grafting investigations.

The Entomologist concentrated during the year on the study of coffee leaf-miners and their parasites, an extremely complex problem owing to the uncertain behaviour of the specific parasites, which varies according to season and locality. Seven coffee leaf-miners are known in East Africa but it is probable that only two of these have ever assumed the status of serious pests. It appears that normally even these two species are controlled entirely by their parasites but at times this balance is upset, for reasons at present unknown, so that serious outbreaks occur which may cause considerable damage. It is hoped that this work will lead to an explanation of such periodic outbreaks and possibly to their control. During this investigation close touch has been kept with the Entomologist at the Coffee Research Station, Lyamungu, Moshi, who is engaged on similar work.

The Soil Chemist returned from study leave, spent in the West Indies and the U.S.A., in November. During his absence Mr. Calton carried on the work of the soils section and made steady progress with the examination of soils received, from collaborating workers, in connection with the East African soil reconnaissance.

It is felt that the time has now come when adequate provision should be made throughout East Africa to amplify the reconnaissance data for the most important areas so that more detailed local maps can be constructed. These would form the essential basis for assessing the practical value of the lands concerned. The results of reconnaissance surveys remain to a certain extent unutilised until this second phase of soil research is carried through. The Soil Chemist elaborates this subject in his report below.

The increased allocation for travelling will allow the Soil Chemist to carry out overdue reconnaissance surveys in Uganda, and probably Kenya, during 1939.

The Biochemist confined his attention almost entirely to investigations into the histology of rotenone in Mundulea, Tephrosia and Derris species. The results of these investigations have not yet been prepared for publication but a forecast of what the general conclusions will be is given in the Biochemist's report below. A more rapid method for determining rotenone and ether extract is also described, using ethyl acetate as the solvent and an optical rotation method for ascertaining the equivalent, and finally the actual, rotenone present.

Seventeen Tephrosia species and varieties were introduced during the year and will be handed over to the Biochemist for analysis after multiplication.

Owing to the absence of one physiologist for half the year, partly through illness, the output of the physiology section was restricted. Mr. Nutman, while in England, was granted an

extension of two months leave for the purpose of developing new apparatus and methods for physiological research, facilities for this purpose being kindly provided at the Imperial College of Science and Technology by Professors Gregory and Dingle. As a result of this work a successful method for measuring small changes in carbon dioxide concentration in an air-stream was devised, based on the absorption of infra-red radiation by carbon dioxide. The apparatus subsequently invented to exploit this method is now being calibrated preparatory to attacking the many outstanding problems connected with carbon assimilation in tropical crops. On page 31 Mr. Nutman indicates the nature of some of the problems that can be investigated. Pending the arrival of this apparatus both physiologists have devoted their time to developing methods for studying transpiration in whole plants in the field. A promising new method for measuring transpiration from attached single leaves under natural conditions was also developed.

Mr. Glover devoted the early part of the year to the study of root systems in sisal under estate conditions; an account will appear in the Empire Journal of Experimental Agriculture.

The effect of growth-promoting substances on *Derris elliptica* cuttings was investigated by Mr. Glover. Beta-indole-acetic acid produced a significantly greater number of roots during early growth, a result which may have practical application if this initial gain is found to be maintained throughout the life of the plant.

With the growing realisation of the practical value of physiological knowledge agronomists are making increasing demands on physiologists. To meet these demands in East Africa there are but two physiologists, both on the Amani staff, whose field of work moreover should embrace all field crops. Two physiologists are all too few for attacking the numerous physiological problems awaiting solution. I am of the opinion that the need for such workers must be considered in the near future by the various authorities concerned in the same way that the need for other specialists was faced in the past, and which has led to the appointment of the present staff of 13 botanists, 11 chemists, 13 entomologists, and six pathologists engaged in agricultural research in East Africa.

The Geneticist, as in the past, has been chiefly concerned with the improvement of sisal and coffee and the cytological study of these crops. The lack of a trained assistant to carry on the routine activities of this section during the Geneticist's absence on leave was particularly felt, continuity being essential in such work. Of the many *Agave* crosses that have been made to date by far the most promising is *Agave angustifolia* x *A. amaniensis*, which promises to combine the high leaf-number of the first-named parent with the valuable qualities of the second. Breeding with this cross will continue, using inbred generations of

A. angustifolia, two of which have produced over 700 and 900 leaves per plant respectively, compared with an average of about 235 for ordinary sisal under similar conditions. On the other hand, all seedlings of *A. sisalana* have proved disappointing, chiefly because of the spiny leaf margins of the progeny, so that further work on this line of investigation is regarded as unprofitable. The cross *A. angustifolia* x *A. sisalana* has also proved disappointing.

In his study of poling in ordinary sisal the Geneticist has found indications that the total number of leaves produced during the life of a plant varies with local conditions and treatment, but in any given locality the variation is not large. It appears from a preliminary analysis of the data that, among plants of the same age class, those developing leaf most rapidly are the first to pole and that the mean yield of fresh leaf from the poling plants in each age group is, in most cases, considerably in excess of that given by the non-poling plants. Should these observations be confirmed later they may possibly lead to changes in planting and cutting practice as they indicate that from the standpoint of yield it is not a disadvantage if plants pole early. The comparative field trial of Blue sisal and ordinary sisal in its third cut gave a significantly higher yield of leaf and unbrushed fibre for ordinary sisal. The total yield of fresh leaf and fibre for the three crops combined shows no significant difference. The results of the fibre tests conducted with Blue sisal at the Linen Industry Research Institute, Lambeg, are not published as they are regarded as confidential by the Tanganyika Sisal Growers' Association.

Apart from the study of inbred families of *C. arabica,* breeding and selection work with coffee has been confined, for the most part, to the improvement of *C. robusta.* Several additions were made during the year to the collection of coffee species intended for breeding purposes.

An examination of the *Aleurites montana* plantations, of which about one hundred acres are now established at Kwamkoro and Amani, show an appreciably lower proportion of male trees than was recorded when the trees first flowered. The possibility of selecting high-yielding strains of *A. montana* from the existing population is probably limited as most of the hundred acres referred to has been planted with seed from two trees, the survivors of the first plants introduced.

In 1939 the Geneticist will carry out preliminary studies amongst the hundred acres of Cinchona planted here in recent years preparatory to carrying out selection work.

The improvement of native food crops is a subject that has not hitherto been referred to in the reports of this station. At the time of my appointment it was, however, laid down that in collaboration with the Departments of Agriculture of the six

East African territories I should draw up a programme of the work required in this direction. That this has not yet been done is largely due to the amount of preliminary enquiries that must be made, for until I have been able to visit representative areas of all six territories, I shall not feel in a position to make proposals. These visits should be completed during early 1939, visits having already been paid to Kenya, Uganda, Zanzibar and parts of Tanganyika. The ideal programme would provide primarily for the extension of the collections of all established local varieties, and their botanical study, on regional experimental stations and, secondarily, the introduction of improved varieties from abroad, through Amani when quarantine is necessary. Selection from amongst these varieties should be followed by breeding work where a sufficiently high standard is not achieved by selection. Such work is already proceeding at certain centres but limitation of staff and experimental stations must govern any proposals for its general extension. The final scheme should be linked with the nutrition work of the medical authorities.

Owing to its situation, the part that Amani can play in selection and breeding work is limited but it is hoped that in an advisory capacity and as a clearing house for information on the subject we can be of much assistance. In this connection the Geneticist will visit certain *Striga* infested regions at an early date to report on the problem and its possible solution.

During the year a precis of the past, present and future work on food-crop improvement by the East African Departments of Agriculture was prepared for circulation to the Departments concerned.

The facilities offered at Amani for the identification of East African plants were fully utilised by the various agricultural, veterinary and medical departments, as well as by the public, so that a considerable proportion of the Botanist's time was occupied with determinations.

The collection of East African plants in the Herbarium is now approaching 35,000 and, at the present rate of increase, will provide valuable material towards the preparation of the Flora of East Africa projected by the Royal Botanic Gardens, Kew.

The Botanist spent three months of the year in Northern Rhodesia with Mr. C. G. Trapnell, Ecologist, accompanying him on his agricultural and vegetational surveys of the north-eastern districts. The Amani Herbarium was enriched considerably as a result of this visit.

A new and improved edition of the Botanist's Swahili Dictionary of Plant Names is in course of preparation. A complete list of native food crops is also being compiled.

As in the past, the Station has benefited very considerably by the extra-official activities of the Secretary whose publications on ornithology and climatology form valuable additions to the Station's memoirs.

The contribution to the faunistics of Mafia Island is of importance because it will enable the peculiarities of Pemba and Zanzibar to be brought into proper perspective and the zoogeography of the East African islands to be discussed as a whole.

The further local data on the reproductive rhythm in birds emphasizes the extremely complicated nature of this fundamental biological problem, which would be an appropriate long-term study for a team of workers.

The critical review of climatic classifications, while referring especially to East Africa, was so planned as to be of general use to all research workers who are concerned with climatic controls.

Interterritorial Coffee Research.

The formation of the Interterritorial Coffee Research Committee marks, it is hoped, an important step towards the co-ordination of agricultural research in East Africa. As Chairman, I feel that the recommendations of the committee may appropriately be referred to in this report.

The committee, consisting of the writer (Chairman) and representatives of the coffee research workers of Kenya, Tanganyika and Uganda, held its first meeting in Nairobi from 11th to 13th April. Its object is the direction of all coffee research in East Africa. The activities of the committee are guided by the industry through the Producers' Committee, which confines itself to the general orientation of research and to advising Government on its financial aspects. The main items of the agenda were the consideration of proposals for an augmented programme of coffee research under the control of Amani and a consideration of the coffee research programmes of the East African territories. The committee's recommendations regarding the augmented programme, which involves the carrying out of a large-scale sand-culture nutrition experiment and the employment of a third physiologist and a genetical assistant, have been referred to the East African Governments together with estimates.

The committee after considering the territorial coffee research programmes made numerous recommendations, certain of which especially concern Amani, e.g., the suggested physiological investigations into (*a*) fruit and bud formation and (*b*) the effect of sprays, and the botanical investigations on (*a*) coffee taxonomy and (*b*) the potential value of the wild *Ficus* and *Albizzia* species as coffee shade. The above recommendations involve additions to the existing Amani research programme

and while initial action has been taken in respect of the last three it is impossible to implement the first without extra assistance for the staff of two physiologists who are already fully occupied with the research programme laid down in 1937.

Possibly the most important recommendation of the committee was that all projected investigations in the territories should be brought before the committee before initiation and all results from experiments circulated to members of the committee as they become available. As a corollary the committee advised that a statistician should be available in East Africa to give expert advice to research workers on the statistical aspect of their investigations.

Other important recommendations of the committee dealt with: the drawing up of a comprehensive liquoring investigation, the possible correlation of crop with rainfall, the standardisation of meteorological equipment, the application of the Roach injection technique to coffee and the desirability of a standard form of description for field experiments.

Administration.

The increased contributions from the East African territories, which were foreshadowed in my last report, took effect during the year under review. The effect of the increase on the Station's work immediately became apparent, especially in the plans I was able to make for the travelling of the staff, for undertaking work with native food crops and, by no means least important, for the initiation of the long-overdue re-housing of the labour force. In March notification was received that the Lords Commissioners of H.M. Treasury had agreed to the continuance of the Imperial contribution of £6,000 per annum for a second period of five years from 1938. The financial statement for 1938 appears on p. 52.

A considerable building programme was carried out by the Engineer during the year, the main items being quarters for a European officer, a large annexe to the Soil Chemist's laboratory and 26 permanent quarters for African labourers. In addition a large programme of necessary repairs, renewals and re-wiring was undertaken and a lathe, planing and morticing machine, electrically driven, fitted in the workshops where much of our apparatus is made.

As a result of over a year's working with non-European typists the experiment of using them may be regarded as a success, provided that they are of at least Grade III standard and that close supervision is exercised. Since the volume of work is greater than could be handled by one European typist as employed prior to 1937, the economy effected by the change is an important one.

The growth of the library has been well maintained during the year. Two bookbinders were trained for the British East African Meteorological Service and the Kenya Veterinary Department.

Amani Plantations.

The appointment of an Assistant Superintendent in March has made for better supervision of labour. Wherever possible labour has been put on a task-work basis while, in addition, an improved system for the keeping of records and costings was introduced. Shortage of labour still remains a serious problem.

Anti-erosion measures on plantations and road sides were carried out, these consisting, for the most part, of contour lines of growing *Vetiver* grass which is found most suitable for the purpose.

A timber survey of the numerous exotic species growing at Amani was carried out by the Forest Department during the year as a result of which those areas which are obviously serving no useful purpose will be felled and replanted with species of proved value.

The acquisition of a 10-acre block of land at Kizugu, at an altitude of 600 ft. and 10 miles from Amani on the Muhesa road, has relieved the situation caused by lack of arable land at Amani for work on native food crops. I have to thank the Conservator of Forests for placing this land at my disposal.

The Redevelopment of Kwamkoro Estate.

During the year a further grant of £2,000 was made from the Colonial Development Fund to bring this scheme* to the production stage. The required areas of Cinchona, Coffee, *Aleurites montana* and *Derris elliptica* have now practically all been established. The financial success of this scheme will, I feel, depend largely on the production of the cinchona areas, the first of which should be ready for cutting in 1944. Cinchona inter-planted recently under old coffee and coffee shade-trees is noticeably better than the larger area planted in the open.

Derris elliptica, of which 25,000 plants are established each year, continues to show promise. A trial consignment of 600 lbs. of dried root, giving an analysis of approximately 10 per cent. rotenone, was shipped to London in May, and sold at 1s. per lb. Yield-trial figures will not be available until the 1939 crop is dug.

The 100 odd acres of *Aleurites montana* planted in 1936 have made satisfactory growth while a certain proportion are recorded as having flowered (*vide* reports of Geneticist and Superintendent).

* *Vide* 9th and 10th Annual Reports.

On the other hand almost the whole of the 10-acre area of grafted Arabica coffee, treated on the intensive system, has now definitely failed, largely due to attacks by white stem-borers and leaf-miners. Most of this area, having been manured, can profitably be used for Derris cultivation, while the remaining small area of coffee that has established itself will be maintained.

The Robusta coffee area to be treated intensively was planted during the year. The large area of Robusta coffee on the extensive system made progress where soil conditions allowed it, but other areas should, I feel, be cut out to avoid unprofitable expenditure on maintenance.

Considerable difficulty has been experienced in obtaining sufficient labour during the year, the local population being extremely scanty and introduced labour usually unsatisfactory.

Since the posting of a Veterinary Assistant to Kwamkoro by the Veterinary Department in June it has been possible to supervise more closely the health of the 150 cattle kept for the production of kraal manure, without which the redevelopment scheme could not be carried through.

East African Central Quarantine Station, Amani.

A record of the plant introductions made through this station during the year is given on p. 51. A considerable quantity of plant material was imported in 1938.

East African Agricultural Journal.

The editing of this Journal continued to be done at Amani. The flow of contributions was not as steadily maintained as before, but at the time of writing (February, 1939) the position is satisfactory, thanks, in part, to the co-operation of the local veterinary departments. There has been a slight drop in circulation during the year, apparently confined to one colony. A desirable improvement in the Journal would be a better quality of paper to allow for a higher standard of photographic reproduction, but this could only be achieved if the circulation increased appreciably.

Acknowledgments.

I wish to record how very much indebted I am to the Directors of Agriculture in all the East African Dependencies for their co-operation and assistance during the year and for the facilities and hospitality extended to me and my officers when touring their territories. I am also indebted to Directors of Agricultural Departments outside East Africa, the United States Department of Agriculture and the Director, Royal Botanic Gardens, Kew, for their help in connection with the importation of plant material.

I have to acknowledge the assistance given me on numerous occasions during the year by the Tanganyika Forest and Veterinary Departments in connection with timber surveys and animal husbandry at Amani and Kwamkoro.

A. GLENDON HILL,
Director.

PLANT PATHOLOGY.

I was on duty for the whole of 1938. My assistant, Mr. Nichols, departed on leave in August. He has continued to take an important part in all the investigations in progress.

Virus Diseases of Plants.

The Mechanism of Transmission by Insects.

Work on this long-range research has been of necessity somewhat curtailed during the year owing to the demands of other projects. However it has been possible to make considerable progress, mostly along lines that have been mentioned in earlier reports.

During the year a second paper in the series on the mechanism of virus transmission by insects appeared in the Proceedings of the Royal Society. It describes studies designed to elucidate the manner in which *Cicadulina mbila* inoculates streak virus into a maize plant, and the factors that determine whether infection follows the contact of infective insects. Individuals, that are known to be able to cause infection if they make a prolonged contact with the plant, vary greatly in this ability, if the contacts are of short duration, such as one hour. The infective ability seems to be determined largely by some factor inherent in the individual; as I report below, I am now trying to discover the nature of this factor. If a group of insects makes contact with a single plant, the group, as is to be expected, will be more likely to cause infection than would a single insect under similar conditions. But here a point of considerable theoretical interest arises. Carsner and Lackey (*Phytopathology*, **19**, 1137. 1929) advanced an hypothesis of mass action by insect vectors, holding that the enhanced infectivity of a group is due to the cumulative effect in the plant of small doses of virus inoculated by the several members of the group. I have advanced a contrary hypothesis, that the effect of each insect on the plant is entirely independent of that of other insects; that sub-infective doses, if inoculated at different points into a plant, cannot combine to give an infective dose; and that the probability of a group succeeding is the probability that it contains at least one member that would have succeeded had it been alone. What amounts to the same thing, that each inoculation is local and independent, had been previously accepted by Watson (Phil.

Trans. Roy. Soc., London, B, **126,** 457-489. 1936) for the transmission of a different virus by an aphis vector. Unfortunately an apparently insuperable theoretical difficulty prevents rigid experimental proof of either hypothesis. It can only be said that my data, like Watson's, conform more nearly with the hypothesis of independence, than with that of mass action. If we are correct, we must conclude that the plant possesses some locally effective mechanism whereby sub-infective doses of virus inoculated into a susceptible tissue are inactivated, and that infection follows only when the dose inoculated at any one site exceeds the minimum. Alternatively, we must postulate that no such thing as a sub-infective dose exists for the viruses considered; that the minimum dose that can be inoculated is effective. Most workers would reject this idea; but I know of no evidence that certainly disproves it. If this second alternative were true, the mass-action hypothesis would of course have no meaning.

Perhaps the most important point brought out in this paper is that there is a threshold period for infection: a *Cicadulina* must remain with its mouth-parts inserted in a leaf for longer than about five minutes before it can cause infection of the plant. On the other hand it can take up virus from a diseased plant during a puncture lasting only 15 seconds. These very short punctures do not penetrate beyond the mesophyll of the leaf, so that we must conclude that in the diseased leaf virus is present in the mesophyll. On the other hand I proved in several ways that the insect must penetrate the phloem in order to inoculate virus successfully. But I found that during the first five minutes of puncture an insect could often penetrate to the phloem, so that it seems certain that the threshold period is not merely the time needed by the insect to reach a tissue susceptible to the virus. There must be some other explanation, but we can only speculate what it may be. If the insect slowly releases virus more or less continuously, then conceivably during the first five minutes it may be unable to release enough to constitute an infective dose. This may be the truth; but on a theoretical argument I have been led to favour an alternative hypothesis, that the insect emits virus discontinuously and only as the result of some stimulus received after puncture has been maintained for more than five minutes. These discontinuously delivered doses might be infective, or perhaps sub-infective; in the latter case they would, on this hypothesis, be independently inactivated in the plant.

Included in this paper were detailed accounts of the behaviour of *Cicadulina mbila* during contact with a leaf and of the course taken by the mouth-parts in penetrating it. The photographs of leaf sections showing the course taken by the mouth-parts during punctures known to have resulted in infection are probably unique.

A third paper in this series is now in draft. It deals particularly with the manner in which the insect excretes saliva and with attempts to demonstrate virus in this saliva. The majority of the experiments were performed several years ago; but I repeated the more crucial ones in 1938. It has proved extremely difficult to obtain any evidence of virus in the insect's saliva. However the few successful results obtained in the earlier work have been confirmed in the later. I have referred in previous reports to the difficulty in understanding how the virus passes from the insect into the plant; but I now think that it is in part explicable if we postulate that the insect emits extremely small quantities of virus and that such small quantities are above the minimum needed to infect a plant. The experimental methods that I have used, as I now suggest, have been too insensitive generally to detect these minute quantities of virus; and only when special modifications of technique were employed were any successes obtained, and then only infrequently.

I am now studying the variability in the infective ability of individual *Cicadulina mbila*. This variability shows itself in two ways: in the frequency with which the insect causes infection (1) during short-period contacts (i.e., one hour) and (2) during a succession of prolonged (i.e., weekly) contacts. I have already referred to the demonstrated variability under the first heading. The normal behaviour of an infective *Cicadulina mbila,* when given a succession of weekly tests without intermediate access to a source of virus, is to cause infection of every plant until it dies. But many insects behave otherwise, and soon become non-infective. The factors determining this loss of infective ability are under study. The duration of the original feed on a diseased plant in part determines the period that infective ability is retained by *Cicadulina,* as Freitag (*Hilgardia,* **10,** 305-342. 1936) has shown for *Eutettix tenellus*. But probably with *Cicadulina* genetical factors play a preponderating part.

In an earlier report (9th Ann. Report, East African Agricultural Research Station, 1936-7, p. 18) I referred to breeding studies with insects showing a low infective ability. An hypothesis was there tentatively advanced to explain the results. A doubt whether this hypothesis could fully explain my observations caused me to postpone publications: and recently I have reopened this line of study. I believe that this work is worth pressing to a conclusion; for there are indications that in other vector species variations in infective ability may be inherited. It is doubtful whether a similar wide application is true of my earlier work on the inheritance by *Cicadulina mbila* of the simple ability to transmit. My paper on the breeding and crossing of pure " active " and " inactive " races (able and unable respectively to transmit) was published as long ago as 1932. Since then

reports have appeared of a few vector species showing apparently genetically inactive members; but with several other vectors no individuals seem to be incapable of transmitting. The only work comparable with that on *Cicadulina* is by Huff (J. prev. Med., **5**, 249-259. 1931), who proved that *Culex pipiens* inherits the ability to transmit the organism of bird malaria.

At the invitation of the Editors of the American *Botanical Review,* I have prepared a paper discussing the whole subject of insect transmission of plant viruses.

Streak Disease of Maize.

Apart from the preceding work, in which the streak virus is used as a convenient material for fundamental investigations, I can report an advance that may contribute to control of the disease locally. Through the courtesy of the Director of the Cotton Breeding Station, Barberton, South Africa, I received seed of certain inbred lines of maize that had shown a high resistance to the streak virus in field trials. Tests of this material at Amani under controlled infection by *Cicadulina mbila* have so far entirely confirmed the claims made for it. The selections were made at Barberton from the Peruvian Yellow Flint and Hickory King varieties. The inbred lines are themselves poor producers, as is to be expected, but they may provide a valuable starting point for breeding types suited to East African conditions. Thus the original selection, for which we are indebted to South African workers, opens the way to a substantial local improvement in maize as a native food-crop; both from the point of view of quantity, by avoiding losses from streak disease, and also in quality, by maintaining the yellow character of the Peruvian type and so ensuring the vitamin A content of this important native food.

Virus Diseases of Cassava.

A paper, by Mr. Nichols and myself, was published in the *Annals of Applied Biology* for November, 1938. In it we described our studies on the local strains of the cassava mosaic virus and on their transmission by the white-fly, *Bemisia* sp. The restricted conditions under which this insect can transmit were mentioned in my last report. No progress has been made in the search for a vector of the cassava brown-streak virus and the manner of its transmission is still unknown. The symptoms of this disease are now becoming known by field workers in the Departments of Agriculture and it has evidently been often confused with mosaic. This virus cannot be neglected when the disease problem in cassava is considered as a whole.

We have also published jointly an account of the experiment in field transmission of cassava mosaic, carried out on land kindly placed at our disposal by the authorities of the Kiwanda

Mission School. A marked seasonal difference in the infection-rate was demonstrated over two successive years. Plantings made in June (i.e. the cool season), and to a lesser extent in May, July and August, survived largely disease-free for the longest time; while those of December to April were mostly diseased within three months. The results may be expected to apply generally to the Usambara foot-hill region, and perhaps elsewhere.

Our main work during the year has been the breeding of cassava types. Among the hybrids between cassava and Ceara rubber and between cassava and *Manihot dichotoma* are a number of very interesting plants. We have also some 300 crosses between the more resistant cassava varieties. All are now being multiplied at Amani in preparation for virus-resistance trials in 1939. Until the results of these trials are available it is difficult to see in which direction we should next proceed. But in view of the promising results so far obtained I think Amani should concentrate on inter-specific hybrids. I am anxious therefore to increase our collection of *Manihot* species, and I acknowledge gratefully the promise of help in obtaining these received from Sir Geoffrey Evans, the Economic Botanist at Kew.

During the year it became increasingly evident that work on cassava virus problems must be seriously handicapped, unless land suitable for experimental trials could be made available. As reported previously, I had carried out certain experiments at the Kiwanda Mission and at the Sisal Experiment Station, Ngomeni. Although the authorities at both places were most generous in their offers of land and other facilities, long distance from Amani involved difficulties in the management and heavy costs for transport. The possibility was investigated of reopening the old Tengeni sub-station, still nominally a part of the Amani establishment, but to this the same objections applied. A suitable site was eventually found in an old clearing on forest reserve land, alongside the main road at ten miles distance from Amani. The Conservator of Forests kindly granted us a cultivation lease for ten acres of this land.

The Superintendent of Plantations being absent on leave, the development of this area was undertaken by myself and Mr. Nichols. It lies in a deep valley, and consists partly of a nearly level flood plain and partly of gently sloping land. It is dissected by the Kizugu stream, which has been canalised in a deeply cut channel. Originally intended for experiments on cassava virus diseases, its scope has been extended to include general experimentation on native food crops.

By this development, the facilities for cassava studies become very satisfactory. Amani is well suited to the maintenance of healthy stocks of varieties, for virus diseases spread here to no

serious extent. Under the high temperatures of Kizugu, the diseases may be expected to spread rapidly; indeed the site is closely similar topographically to that at Kiwanda where the recent field infection experiment was successfully carried out.

The first resistance trial there was planted in November, 1938. It includes 100 local and imported varieties laid out on a triple lattice design. This design was chosen after consultation with Mr. F. Yates of Rothamsted Experiment Station, for whose help my thanks are due.

The introduction of exotic cassava varieties through quarantine has continued. To date 105 varieties have entered quarantine, while 32 others have been introduced to Amani from East African sources. Mention should be made of an excellent collection of nearly 60 Brazilian varieties obtained through the co-operation of Mr. Sampson at Kew and Dr. Harland. Forty-six varieties in all have so far been distributed to most of the East African Departments of Agriculture. Reports on the behaviour of the majority of the varieties introduced from overseas do not encourage any particular optimism; nor, it must be admitted, is it very likely that factors for resistance will appear in varieties from countries where East African viruses do not occur. The question arises whether, now that Amani is in a position to carry out its own resistance trials, we should not postpone further distribution to Departments until we can select from our own experience the more promising varieties.

I believe that co-operation with Agricultural Departments on cassava virus problems is now on a satisfactory footing. I have made personal contacts with the Departmental officers mainly concerned, by visits to the Experimental Stations at Morogoro and Kilifi, and during visits to Amani by the Director of Agriculture, Zanzibar, and one of his officers, Mr. Johns. These contacts have been maintained by frequent correspondence. It is desirable that I should visit Uganda at an early date, since up to the present it has not been possible for me to acquaint myself at first hand with the cassava work in progress in that country.

Virus Diseases of Passion Fruit.

Towards the end of 1937 information reached Amani of an outbreak of a suspected virus disease in Kenya passion-fruit plantations. It seemed desirable that I should attempt to assist the Kenya Department of Agriculture in devising measures for controlling this disease, although not specifically on my programme. I therefore visited Kenya in February and October, 1938.

As a result of these visits and subsequent studies at Amani I was able to confirm the presence of a virus in one form of the disease. It can be transmitted mechanically by juice transfer, and can be spread experimentally by the use of a contaminated

pruning knife. There are however other forms of disease in certain Kenya plantations that resemble in some respects the disease considered above, but have not so far been successfully transmitted to healthy plants. The reason for this is at present obscure.

In its typical form the Kenya disease resembles that known as " Woodiness " in Australia, where it is reported to cause serious losses and not to respond to measures for its control. The recognised methods of control have been suggested to the Kenya Department of Agriculture; but whether in East Africa they will prove more successful than in Australia remains to be seen.

During my second visit to the Kenya plantations, I was accompanied by Dr. R. M. Nattrass, Senior Plant Pathologist to the Department, to whom the investigations of this problem has now been entrusted. The opportunity was taken for a very full discussion, and we agreed to recommend a programme of research, in which I shall co-operate. In our opinion the most hopeful line of work is to attempt to obtain a resistant strain of plant; perhaps by selection within the species, *Passiflora edulis,* or, more probably, by interspecific hybridisation. The first step is to bring together as large a collection of *Passiflora* species as possible. A number of botanical institutions have already responded to our requests for seed, while Sir Geoffrey Evans has approached several correspondents in South America. This line of research is naturally a long-range one and at best practical results cannot be expected within several years.

" Sudden-death " Disease of the Clove Tree.

Owing to the appointment of a special research officer for the study of this disease, I have not myself undertaken any further work. Dr. A. H. Campbell visited Amani, in the company of the Director of Agriculture, Zanzibar, in November, 1938, when the problem was fully discussed and lines of investigation considered.

Results of the spectroscopic analysis of clove material, to which I referred in my last report, have been received. The analyses were performed by Dr. A. H. Lewis, by kind permission of Messrs. Imperial Chemical Industries Ltd. Although the analyses do not give any clear lead to the cause of " sudden-death," they suggest points that, in Dr. Lewis's opinion, justify further study. The sampling of material in the field has been placed in Dr. Campbell's hands.

Our thanks are due to Dr. Lewis for the valuable work carried out on our behalf.

H. H. STOREY,
Plant Pathologist.

ENTOMOLOGY.

During the whole year I have been engaged on a study of the leaf-miners attacking Coffee. This subject is also being investigated by Mr. F. B. Notley, Entomologist at the Coffee Research Station, Lyamungu, with whom close touch has been maintained. I have visited Lyamungu on two occasions, in April and September, and Mr. Notley spent some days at Amani in December.

Seven species of coffee leaf-miners are now known to occur in East Africa, six of them Lepidoptera and one a Dipteron. Of three of these, however, I have little or no first-hand knowledge. It is probable that only two of the seven species, both belonging to the genus *Leucoptera* (Lyonetidae, Lep.), have ever assumed the status of serious pests in East Africa. These two species have up to the present been known as *L. coffeella* Guér. and *L. daricella* Meyr.: while it is probable that the former is correctly named I have no doubt that the latter is not. *L. daricella* was originally described from Queensland and its host-plant is stated to be *Plumbago capensis*. Such few details of its bionomics as are known (Bainbrigge Fletcher, *Mem. Dept. Agric. India Ent. Ser.* VI, No. 1, pp. 174 and 215, 1920) differ materially from those of the African species attacking coffee.

Sir Guy Marshall, Director of the Imperial Institute of Entomology, has kindly arranged that Mr. R. Washbourn of the Institute should undertake a study of the taxonomy of the genus *Leucoptera*. Material for this from various localities in East Africa has been sent, but Mr. Washbourn's conclusions are not yet to hand.

Since it is clearly undesirable to continue the use of possibly inaccurate names, I propose for the present to refer to these species as follows:—

Species A. Previously known as *L. coffeella*. The smaller of the two, eye-spot at apex of wing darker and more conspicuous. Eggs laid in small random groups, or singly, anywhere on the upper surface of the leaf. A sun-loving species, seldom abundant under heavy shade.

Species B. Previously known as *L. daricella*. On the average rather larger than sp. A, the eye-spot pale and inconspicuous. Eggs laid in rows of most usually four to eight close to the mid-rib or a main vein, their long axes at right angles to the vein. In comparison with sp. A it has a distinct preference for ovipositing on those coffee bushes, or parts of bushes, that are shaded. Mines of both species may, however, sometimes be found on the same leaf.

The species studied by Box (*Bull. ent. Res.*, 14, p. 113, 1923) in Kenya under the name *L coffeella* seems to have been sp. A. Through the kindness of Dr. R. H. LePelley I have received

living specimens of coffee leaf-miners from two localities near Nairobi, which appear to be identical with sp. A from Amani and Moshi. Moreover they had the same habits as, and interbred with, sp. A from Amani. It should, however, be remarked that according to Box the species he was studying extruded the pupal case from the cocoon on the emergence of the adult. This habit has never been observed in either of the species of *Leucoptera* that I have dealt with, including those recently received from Kenya.

The life-histories of both species A and B have been worked out in some detail in the laboratory, but it is not yet known to what extent the information obtained is applicable to field conditions, especially as regards two important points—the number of eggs laid and the period during which egg-laying continues.

Much time has been devoted to studying the parasites of these species of *Leucoptera*. Most of the 16 species described or mentioned by Ferrière (*Bull. ent. Res.* 27, p. 477, 1936) have been found, and many of them bred for several generations. Two of them (*Closterocerus africanus* Wat. and *Teleopterus violaceus* Ferr.) have proved to be obligate hyperparasites, while one (*Pleurotropis coffeicola* Ferr.) can be either primary or secondary. This in itself is not an uncommon occurrence among Eulophidae, but it is of considerable interest that in the Moshi district *P. coffeicola* is a common primary and apparently but seldom a secondary, whereas in the neighbourhood of Amani it is the most abundant secondary but, up to the present, has very rarely been found as a primary. There are, however, indications that at the time of writing (January, 1939) it is rapidly increasing as a primary parasite of species B. It seems certain that I have not confused two different species, for individuals that have developed as primaries have laid eggs that developed as secondaries, and *vice versa*. Moreover primaries from Moshi have been mated with secondaries from Amani. This species demands further study.

In addition to those previously recorded, nine primary and two secondary parasites occur at Amani, as well as several others of which only one or a few individuals have been found, and which may, therefore, be only facultative parasites of *Leucoptera*.

Most of the primary parasites are known to attack both species of *Leucoptera*. There is, however, one conspicuous exception—*Apanteles bordagei* Giard seems to be specific to sp. A and has not even experimentally been induced to attack sp. B.

It has been ascertained that the parasite complex varies very greatly not only with the season of the year in any one locality, but also in different, even though neighbouring, localities. This was perhaps not unexpected, but it adds considerably to the difficulty of understanding the problem as a whole.

As a general rule both species of *Leucoptera* are efficiently controlled and the control is, apparently, entirely due to parasitism. There are, in fact, several species any one of which should theoretically be capable of exercising a sufficient control, if one could rely on the data obtained in the laboratory concerning the biotic potential, the length of adult life, and the duration of the life-cycle of the parasite compared with those of the host. But in the field, though natural control may be maintained for months on end, sooner or later outbreaks do occur; an elucidation of their causes is one of the principal results to be hoped for as a result of these investigations. The study of the causes of fluctuations in insect populations has not received the attention it merits; at least as regards multivoltine insects in the Tropics, on which very little detailed work has been published apart from Taylor's account of *Promecotheca* in Fiji ("The Biological Control of an insect in Fiji", T. H. C. Taylor, 1937). It is as yet too early to adduce any hypotheses to account for outbreaks of Leucoptera. However, the most promising lines of investigation appear to be as follows. There may be some factor, possibly climatic, that on occasions reduces the duration of the oviposition period. In the laboratory this period may be as much as four weeks (for species A, possibly less for species B), which is nearly as long as the whole time required for development. If this were invariably so in the field, the population would inevitably consist of individuals of all ages. (The destruction of all stages except, for instance, the eggs, would of course produce a temporary "one-stage condition", but this would begin to disappear in the very next generation.) Actually it does not always do so and, at least at the beginning of an outbreak, there is a noticeable preponderance of individuals of approximately the same age, though it is not suggested that this preponderance is so complete as that which Taylor found in "one-stage outbreaks"* of *Promecotheca*. For the past two months a "few-stage" outbreak of species B has been in progress near Amani, and I understand that Mr. Notley has encountered a similar state with species A at Lyamungu.

I think it is very probable that some dislocation of the normal condition, arising no doubt from a variety of causes, may very often be the reason for the wide fluctuations in population of

* There appears to be a need for adjectives to designate populations of which the members are at a given moment predominantly (a) all of about the same age (b) of comparatively little difference in age (c) of considerable difference in age, yet still with some age-groups unrepresented (d) of all ages. (a) and (b) correspond to Taylor's "one-stage condition" and "multiple-stage condition" and for the present I adopt these terms with the addition of "few-stage" to indicate the intermediate conditions. I think, however, that "all-stage" is preferable to "multiple-stage" and I should have preferred words indicating "age" rather than "stage". But I have failed to coin words derived either from the Latin *aevum* or the Greek αἰών, that are not either unwieldy or cacophonous. I should be grateful for the suggestions of a philologist on this matter.

insects of which, as a rule, all stages occur together and are then adequately controlled by biotic factors either with or without assistance from physical factors. At the beginning of a " few-stage " outbreak the percentage of parasitism is very low. The reason for this is not yet known, but I already have indications that competition between two or more species of parasites may result in their combined efforts being less effective than would those of one species by itself. It is hoped that the information that has been gained on the life-histories of the principal parasites may enable this point to be elucidated.

A hypothesis that Hopkin's " Host-selection principle " might be applicable to the parasites of *Leucoptera,* i.e. that individuals bred on one species would continue to select that species in preference to the other, seems to have been disproved, at least for a few of the commoner species.

The remaining species of coffee leaf-miners have received comparatively little attention.

Species C, probably a species of *Gracilaria,* makes large irregular blotches on the lower surface of coffee leaves (arabica only). It is not uncommon at Amani, but appears to be well controlled by parasites. Large numbers of the larvae of this species die when quite small, from some cause as yet unknown. Such premature death does occur with both the species of *Leucoptera,* but is comparatively rare.

Species D is a Lepidopteron of which I have so far been unable to breed the adult. It makes small serpentine mines on the upper leaf surface, only one larva being found in each mine. It occurs in small numbers near Amani, and is very unlikely to be of any economic importance.

Parectopa aletreuta Meyr. was recorded by Ritchie (*Ann. Rept. Dept. Agric. Tanganyika,* 1935, p. 96) from Bukoba, where he stated that it was the predominant miner. I have no personal knowledge of this species, but some mines in leaves kindly sent from Uganda by Dr. T. H. C. Taylor all appeared to be the work of *Parectopa.* This species has not been recorded from Kenya or the eastern part of Tanganyika.

Acrocercops chalybophares Meyr. has also been reported from Bukoba by Harris (*Ann. Rept. Dept. of Agric. Tanganyika,* 1936, p. 91). So far I have not met with this species.

The Dipterous leaf-miner is a species of *Melanagromyza.* Though not uncommon it is unlikely to do appreciable damage. It makes a serpentine mine just beneath the upper epidermis of the leaf. Though the mine is a large one for such a small larva to make, the greater part of its area often heals up and little harm appears to be done to the leaf. Four species of parasites have been bred from it and these seem able to keep it under efficient and permanent control.

T. W. KIRKPATRICK,
Entomologist.

SOIL SCIENCE.

Until mid-November of the year under review I was absent on leave, having spent an extension of leave of about seven months on study visits to the West Indies and the United States. For the greater part of the year, therefore, Mr. Calton was in charge of the laboratories and was single-handed, except for two Africans, who are becoming increasingly skilful as assistants in some forms of routine analytical work but cannot be left to conduct any of it independently.

Soil Reconnaissance.

Little new ground has been broken this year, except in Northern Rhodesia through the continued collaboration of Mr. C. G. Trapnell, who has sent in material representing the soils found under various vegetation types, chiefly deciduous savannah woodlands, which he has been studying during the course of the ecological surveys on which he has been engaged. Two profiles representing the soil complex of the Kitui District, in the south-easternmost part of the highlands of Kenya Colony, were received from the Assistant Agricultural Officer, Kitui, through Mr. Colin Maher, whose comprehensive reports provide the necessary background for interpreting them. Some additional material from sisal-growing districts has been collected by Mr. Glover, Plant Physiologist of this Station, in connection with his investigations of root-systems of sisal.

The opening of a small sub-station at Kizugu in the foothills of East Usambara near Amani gave opportunity for further study, in this humid region, of the relationships between soils found in close association and on the same kind of parent material but under different conditions of slope and drainage. During his visit to Kingolwira, Morogoro District, Tanganyika, in connection with the fertility studies reported on below, Mr. Calton explored these relationships under the much drier conditions of that Experiment Station (which has a rainfall not exceeding 30 ins. and a long dry season) and on the more mature topography that characterises its site. He discovered a variety of unfamiliar types and recommended a detailed soil survey. By " survey " here is meant not only the recognition of the various types, as in a reconnaissance taking a couple of days, but a plotting of their distribution with sufficient accuracy to allow their areal proportions to be assessed and their fundamental relationships to be worked out. This task, on an area the size of an experiment station, would take perhaps a couple of weeks if a base map were available on a suitable scale. It is worth emphasizing that the results of a soil reconnaissance remain to a considerable degree unutilised until this second stage of investigation is embarked upon.

What is true of small areas is true *a fortiori* of larger ones. A soil reconnaissance journey made through a region, or collections of material sent in from it by some interested field worker, are valuable in indicating what kinds of soil there are and their general relationships. Any conclusions drawn, e.g., on agricultural practices or on questions of land utilisation, are however, subject to grave risk of error until the quantitative element is introduced into the investigation by at least some attempt to expand the data of single-point observations and linear traverses into a map. It is appropriate in this report of the tenth full year of activity of the Amani soils laboratory in the field of soil reconnaissance, to draw serious attention to these considerations, and to urge that soil survey should be given its place, with due financial provision, in programmes of research bearing on land and its uses in East Africa.

An example of expansion of reconnaissance observations into a map falls to be reported this year from the Shinyanga area in Tanganyika, not as a direct outcome of planned agricultural or geographical investigation but as a by-product of the personal enthusiasm and liberal outlook of a field geologist. In the Eighth Annual Report, p. 17, I described some travelling in western Tanganyika undertaken in late 1935 and early 1936 with a view to obtaining a preliminary insight into the soils of the Lake and Western Provinces. My full report on that journey, circulated in typescript, came under the notice of Dr. G. J. Williams, who was engaged in 1937 and 1938 in the geological mapping of the Shinyanga area. He was led to include soils in his investigations, using my tentative account of the soil types under their Sukuma names as a basis for further study. He has now sent for my information (with the permission of the Chief Geologist, Dodoma) a generalised soil map of the Shinyanga Degree Sheet on a scale of 1 : 250,000. He considers it somewhat diagrammatic on that scale but it would fairly represent the accuracy of the observations it reduced to 1 : 500,000, or about 8 miles to the inch. The six soil types represented in the legend are broadly defined and would require to be further differentiated in a survey intended to be of direct help in the practical land-utilisation problems of the area; but at any rate the reconnaissance stages have been carried an important step further by this valuable piece of collaboration. Dr. Williams gives along with his map a very helpful analysis, from the geological viewpoint, of some of the genetic factors that have operated in determining the distribution of the soil types. He considers that most of the occurrences of red earths in that region are relics from the last humid period; they are not products of current climatic weathering. This is an interesting extension of conclusions I had reached, from pedological considerations, about red earths in other rather drier parts of East Africa, such as the Masai Steppe and the Ugogo plateau, and with regard to some at least

of the red earth types, also in the Tabora-Shinyanga-Mwanza region. As a generalisation everywhere valid in that region, it now calls for further examination in the light of all the evidence.

In the laboratory, work has proceeded on material in hand from previous reconnaissances or sent in by collaborating workers in the field. The soils chiefly given attention were a collection received from Tabora in 1937 (see Tenth Annual Report, p. 16), the Physiologist's samples from the sisal areas, and some of the Rhodesian samples. The Tabora data were held for my consideration on my return from leave, and have not yet been reported on pending the results of further analyses now in hand.

Failure of grain crops on certain newly-cleared bush lands.

The analytical work undertaken in conjunction with the Tanganyika Department of Agriculture's field experiment on this subject at Kingolwira near Morogoro (see Tenth Annual Report, p. 16-17, and a further paper by N. V. Rounce to appear in the E.A. Agric. Journ., March, 1939) has occupied a good deal of laboratory time during the year. The analytical programme was designed to bring out, with the minimum of laboratory work, the significant differences, if any, either existing originally or due to treatment, between the soils of the various plots. It was necessary first of all to obtain an estimate of the soil variability on the uncleared land by performing the desired analyses in duplicate on a sufficient number of samples that purported to be replicates of each other. With knowledge of the standard error of sampling thus obtained, it could then be judged by further analyses whether the act of clearing had introduced additional variability due to uneven disposal of trash, etc.; and finally the identity or otherwise of the soils of the different plots as now found, after one or two years of cropping under differential treatment as to cultivation, could be tested. Analyses undertaken included estimations of organic carbon by dry combustion, total nitrogen by the Kjeldahl method, and hence carbon/nitrogen ratio; phosphorus by the Troug method, exchangeable calcium and potassium, lime-requirement by the Hardy-Lewis method, pH and exchange pH by the hydrogen electrode, volume weight, proportion of water-stable aggregates, moisture-content at standard suction corresponding to pF = 3 on Schofield's scale, and rate of nitrification on incubation at standard moisture content. This heavy programme has been completed by Mr. Calton on the 1937 samplings, and the results have been assembled and given a tentative interpretation by him.

The significant result that appears to emerge is that the organic matter of once- or twice-cropped land undergoes nitrification more quickly than that of newly-cleared land, and that the soil

in maize has had a greater draft made upon its available nitrogen than the soil in cotton; the soils otherwise being, within the limits of the tests, approximately similar as regards all the other properties examined. It appears from this that the original surmise made when the question was first raised by Mr. Rounce, namely that the non-success of a grain crop in the first year of clearing of lightly-treed grassland was due to insufficiently rapid availability of nitrogen-supply, has some support in the laboratory findings. This conclusion is of course tentative; the 1938 samplings still await attention in the laboratory and the experiment is, I understand, to continue a further year.

Travelling.

As has already been mentioned, Mr. Calton visited Kingolwira in August and extended his journey to Mpwapwa; *en route* he also renewed touch with the Agricultural Chemist in Zanzibar, and in Dar es Salaam discussed the scope of a suggested exhibit of soil profiles of Tanganyika to be installed in the new Museum there.

My visits to the West Indies and to the United States under authority from the Colonial Office and with the financial assistance of the Carnegie Corporation of New York are being reported upon separately and the report, when approved, will be circulated during the coming year.

G. MILNE,
Soil Chemist.

BIOCHEMISTRY.

During this year I have concentrated almost entirely on research into insecticidal plants.

Fundamental Work.

Following the work by Nutman and myself on the histology of rotenone in *Derris elliptica* root, I have carried out a complete examination of a similar nature on all parts, and at all stages of growth from germination onwards, of *Mundulea sericea* (*suberosa*), *Tephrosia Vogelii* and *Tephrosia candida*: in addition I have examined all such parts as could be obtained of *Derris elliptica, D. malaccensis, D. uliginosa* and *Tephrosia Ehrenbergiana,* and the seeds and seedlings of *Tephrosia toxicaria.*

This work has necessitated the cutting and microscopical examination of many tens of thousands of sections. A large mass of results has been obtained and I am now engaged in writing them up. These results do not lend themselves readily to summarization, but some general conclusions may be mentioned.

The presence of rotenone (by rotenone I here also include other similar toxic substances) is far more widespread in some plants than was expected: thus almost every part of T. Vogelii, including all the floral organs, contains it.

Rotenone occurs in some organs in normal cells, whereas in others it is found in morphologically distinct cells, often of considerable size.

Seeds of all the above plants contain rotenone. On germination this either disappears entirely or greatly diminishes in amount in all the five species of which I have been able to obtain viable seeds. This suggests that the rotenone is of some definite use to the seedling plant.

Except in one instance I have not obtained any other evidence of lability of rotenone: in all parts except the seed, but including the seed testa, rotenone appears to remain undiminished after the plant, or organ, has withered and died.

This research, which is entirely observational, has suggested many provisional hypotheses to be tested by experiment, and I have carried out some preliminary work of this nature.

I have found that small *Derris elliptica* plants when kept in the dark until dead have not apparently lost any rotenone from their roots, although much of the hemicelluloses has been used as food by the plant. Rotenone in *Derris* root does not, therefore, appear to be capable of utilization as food reserve.

Lower, woody cuttings from *Derris* stems root more readily, as would be expected, than upper, green ones: as, however, the former contain rotenone whilst the latter do not, I have experimented by introducing both *Derris* root sap and stem sap into the upper green cuttings, both by injection and suction. No increase in percentage rootings was obtained; in fact, a slight reduction occurred.

Attempts to extract from *Mundulea* seeds an enzyme that would act on the rotenone in the seeds have so far yielded inconclusive results.

A simple deficiency experiment was carried out with *Derris* elliptica in sand culture. Almost complete deficiencies of potash, calcium and phosphorus and partial (95 per cent.) deficiency of nitrogen were contrasted with full nutrient. The results are interesting. Full nutrient, potash deficient and nitrogen deficient solutions gave nearly equal amounts of root; calcium deficient gave half the amount; phosphorus deficient only one fifth. The percentage of rotenone in the roots was surprising: that of the plants grown in full nutrient solution being only about half those with the other solutions.

Whilst it is necessary to repeat this experiment on a larger scale, the present results indicate that Derris is likely to give a more toxic root in soil poor in potash or nitrogen, than in

rich soil: they also indicate that serious shortage of calcium or phosphorus, especially the latter, is detrimental to growth, whereas similar shortage of potash or nitrogen makes little difference.

The work just completed concludes the first stage of my fundamental research into the vegetable insecticides: before I proceed with the next stages I wish to consult experts in England as to the best means of attacking the problems, i.e. the mode of formation, and the functions, of the toxic substances.

The Superintendents of Plantations have grafted, for me, a number of different Derris species and strains on each other, in order that I may study the course of rotenone formation under these conditions: e.g. *D. elliptica* on *D. polystachis* (which contains no rotenone) and vice versa.

I should like to acknowledge the assistance and advice given to me by Mr. Nutman in connection with the botanical aspects of these investigations.

Plot Experiments.

The two *Derris* plot experiments, which were described in last year's report, are in good order.

Mundulea.

As I have no assistant it has not been possible to commence many items: thus work on selecting more toxic strains of *Mundulea* cannot be undertaken.

Preliminary results from previous years suggested that a seasonal variation in the rotenone content of Mundulea bark might occur. More detailed sampling, throughout a year, has shown that no evidence of such a variation can be demonstrated.

Rotenone Determinations.

In preparation for the large number of analyses that must be made when the Derris plot experiments are dug, I have worked out a more rapid means of determining rotenone and ether extract, which consists in extracting with ethyl acetate and evaporating to exactly 25 cc.: the optical rotation is then determined and from a previously prepared curve the amount of equivalent rotenone is determined: this value is then used in a second curve for the amount of actual rotenone. The second curve was prepared by plotting the equivalent against actual rotenone (estimated by ordinary methods) for a number of different samples. This method gives results correct to $\pm$ 0·5 per cent.; but it must be emphasised that any particular set of curves are probably only applicable to one strain of *Derris*, and not of general use. At the same time the amount of ethyl acetate extract is determined, and a series of trials has shown that this is 1·3 times the amount of ether extract.

Information on *Derris*, both on the fundamental and the commercial side, is slowly accumulating, and I hope that in a few years' time I shall be in a position to write a monograph on Derris in East Africa.

Fish.

The first consignment of goldfish, obtained for breeding for piscicidal tests, all died of fungus disease. A second consignment of nine fish brought from Europe have now increased to about 150. In June about 200 Gambusia ("millions") kindly supplied by the Director of Medical Services, Zanzibar, were introduced and the survivors have now begun to breed.

Essential Oils.

No new work has been undertaken this year, but I have completed the analytical work on lemongrass oils, and have written up the results of the experiments which I have been carrying out for some years.

Briefly, the grass could be cut about once a month in Amani; the monthly yields of grass and of oil were not apparently dependent on the rainfall, season, etc.; but the citral content of the oil was found to vary inversely with the rainfall. This last fact should prove of value if I am able at some future date to undertake fundamental research on essential oil plants.

A number of samples of citrus oils have been examined for local planters.

Kweme Nuts.

Kweme nuts are becoming an increasingly important crop in the Usambaras, and it was thought necessary to investigate methods of removing the bitterness from their shell.

The flesh of the fruit contains an intensely bitter substance, probably alkaloidal, and the seeds (i.e., the nuts) retain some of it on removal and drying. It does not appear to be developed in the seed cells, but merely soaked into the seed. The outer basket-like net and the shell are very bitter. There is some dispute as to whether the inner skin is also bitter, but in every nut I have tried it is so, to a greater or less extent.

It was understood to be desirable from the Usambara growers' point of view that the bitterness should be removed from the nut prior to husking. After several trials I found that washing in running river water for 48 hours completely removed all bitterness from the net, shell and skin. I have found that the nuts so treated keep for several months if thoroughly dried afterwards.

Other Work.

At the request of the Plant Pathologist I have recently worked out a rapid method for determining the relative amounts of cyanogenetic glucosides in cassava roots. It is based on the

speed of colour formation when hydrocyanic acid acts on sodium phenate paper: he has not yet put the test into practice.

I have carried out a number of routine analyses during the year, mostly of *Derris* root.

In January I visited the coffee areas of Moshi, Arusha and Oldeani: I also visited the Taveta estates to inspect *Derris*.

R. R. WORSLEY,
Biochemist.

PLANT PHYSIOLOGY.

I returned to Amani on July 22nd after an absence of a year. Part of this time was sick leave, part normal vacation leave, and part an extension granted to enable me to do work in England that was hardly possible in Africa. This prolonged absence has naturally reduced the output of the section during the year.

I can, however, report progress with the five-year programme. Actual results have been few, since the development of methods must naturally precede work in the field. This preliminary stage always takes much longer than the work itself. Since these methods can be applied to any crop I shall report on them first.

Development of Apparatus and Methods.

For continuing and extending work on the carbon exchange of plants it is necessary to use more efficient methods for measuring small changes in the concentration of carbon dioxide in an air-stream than have hitherto been used. This is especially so when the carbon exchange of a large plant such as a coffee tree is being studied. Through the courtesy of Professors F. G. Gregory and H. Dingle, I was given facilities for work on this problem in the Botany and the Astrophysics Departments of the Imperial College of Science and Technology, and I wish to express my gratitude to them for their interest and help. A successful physical method based on the absorption of infra-red radiation by carbon dioxide was devised, and the apparatus is now being assembled and calibrated through the kind offices of Professor Gregory. It is intended that in due course a joint communication shall be published.

This apparatus should facilitate progress with the following items on our programme: —

(1) " The measurement of the photosynthesis of complete coffee trees, followed by a determination of the march of assimilation rate in the field . . . . with especial reference to shade."

(2) " The influence of sprays on the photosynthesis of *C. arabica*."

(3) " The determination of the photosynthetic behaviour of *C. robusta.*"

It can, or course, be used for any other purpose involving the measurement of carbon dioxide concentration. If time permits, work on the carbon exchange of *Agaves* may be undertaken with its aid.

Since my return Mr. Glover and I have devoted all our time to the development of methods for the study of transpiration. I have completed a method for studying the march of the transpiration rate of whole plants under field conditions. Some of the necessary equipment has been ordered from England and the remainder has been made in the Amani workshops. I am greatly indebted to Mr. Greenwood, who has assisted with the design and facilitated the construction of much of the apparatus.

Mr. Glover has been working on a method for recording the " instantaneous " value of the rate of water loss from leaves still attached to the plant and exposed to natural conditions, transpiring into air of normally varying humidity. Many attempts to devise such a method have been made in the past, but all have hitherto failed, because of the extreme difficulty of the problem. If the method now being tested is successful, a very potent weapon will be available to plant physiologists. Mr. Glover reports as follows on the results so far achieved:—

> " A new method is being developed for measuring, under natural conditions, the rate of transpiration of a single leaf. The measurement is of " rate " and does not involve any estimate of time. Any such method, dealing with a single leaf, will permit of easier analysis of the factors controlling transpiration than if the average of all the leaves of a plant were being considered.
>
> " The apparatus devised can measure continuously and automatically the absolute differences in water content between two different streams of air. It is now a successful laboratory method, and I hope that further work will enable it to be used in the field. It gives results of the same order as those obtained by the Senior Physiologist's on whole trees.
>
> " In connection with this research, studies have been made of the diurnal variation in water content of coffee leaves."

These two methods, the first complete and the second promising, should play their part in the solution of many East African problems, agricultural, ecological, and hydrographical. With them, the following items on our programme can be completed:—

(4) " Transpiration studies of *C. arabica* with especial reference to shade."

(5) " Transpiration studies of sisal in relation to climatic and soil factors."

Coffee.

While I was in England I discussed the Coffee Nutrition Experiment (put forward in 1937 by the Biochemist and myself jointly) with various authorities, and I received useful suggestions and criticisms. The scheme is now under consideration by the East African Governments.

Preliminary work in Amani on the transpiration of rooted coffee trees has given interesting results. Because of their somewhat unexpected nature, however, confirmation in more representative districts must precede any detailed reference to them. This I hope to obtain early next year. It is already clear, though, that the amount of water needed by the coffee tree is surprisingly small.

Sisal.

During the early part of the year Mr. Glover completed the study of the root systems of sisal in certain East African soils. This work confirmed the results previously obtained, summarised in the Amani Annual report for 1937-8. An account of his researches has been accepted for publication in the *Empire Journal of Experimental Agriculture*.

Derris.

No work on Derris is included in our programme, but the ample material available at Amani, and the importance of the crop, made it worth while to test the effect of a growth hormone on the rooting of cuttings. Mr. Glover has published a full account of this work in the East African Agricultural Journal. and summarises his results below:—

> " Cuttings of *Derris elliptica* treated with a 1/20,000 solution of beta-indole-acetic acid produced a significantly greater number of roots during a period of three months than did untreated controls. If this initial advantage is maintained during the life of the plant it may be possible to obtain an increased yield of root."

Travelling.

While I was on leave I paid a visit to the sisal section of the Linen Research Institute at Lambeg in Ireland. I also visited certain Jute spinners in Dundee in company with Mr. Ewing, of Lambeg. The costs of both these visits were met by the British Empire Producers Organisation, to whom I am grateful.

I also visited Rothamsted, Cambridge, London, and Exeter to discuss various aspects of my work with specialists.

I have done no travelling since my return to Africa, save a flying visit to Arusha to inspect experimental material.

In the early part of the year Mr. Glover travelled in the sisal districts in connection with his root-system work.

F. J. NUTMAN,
Plant Physiologist.

PLANT GENETICS.

Active participation in the work of this section was confined to four months of the year as I was absent on leave from 3rd April to 28th October. During the month of March I was away from the station visiting the Coffee Research and Experimental Station, Lyamungu, Moshi, and coffee experimental stations in Kenya and Uganda.

While in England I represented the East African Agricultural Research Station at the Conference of Colonial Directors of Agriculture and at the Empire Cotton Growing Corporation Conference. At the invitation of the Board of Trustees for Sisal Research I visited Lambeg to see the work of and discuss problems raised by the Sisal Section of the Linen Research Association.

During my absence on leave the work was carried on by my African staff under the supervision of the Director, the acting Superintendent of Plantations and the Assistant Superintendent.

Agaves.

A few more species of Agave have been added to the collection maintained for breeding and cytological work, and several reintroductions made to replace casualties. One hundred and seventeen species and varieties are now represented.

In earlier reports I have stated that the policy has been to transfer as many plants as possible of the various species to the Sisal Experiment Station, Ngomeni, there to establish them in case they are required for future breeding experiments. Several of the species that have already been transferred, particularly those belonging to the Americanae group, have proved very susceptible to sisal weevil attack; other species to leaf scorch in varying degrees of intensity. This information is very valuable but it is obvious that a reserve supply of the more susceptible forms will have to be maintained at Amani, where they are not so exposed to these disabilities, until such time as their possible merits as parents have been determined.

Seedlings of *A. lechuguilla,* the species providing a fibre used in brush manufacture, have made very slow progress and have not yet attained a size that would justify their transfer to the field.

The study of the development of individual plants of *A. sisalana* is nearing completion. They were cut for the third time in August. Many plants have already poled. In this material there appears to be a marked seasonal incidence of poling. The inflorescences of all plants poling during 1937 appeared during the period January to March. During 1938 the period was January to April. The behaviour during 1939 cannot be predicted with certainty but many of the remaining plants appear to be near the poling stage now (December, 1938).

Michotte* quotes a theory attributed to Dr. Warburg that *A. sisalana* can only produce a certain maximum number of leaves during its life. The data available from poling plants in these experiments indicate that the total number of leaves produced varies with local conditions and treatment but in any given locality the variation is not large. I have not yet been able to complete the analysis of the data collected during the year so that these and the following observations are merely tentative.

Among plants of the same age group i.e. raised from bulbils of one parent plant, it appears, from a preliminary survey of the data, that those developing most quickly, judged by the increase in leaf number, are the first to pole. The mean yield of leaf given by polling plants in each age group is in most instances considerably in excess of that given by non-poling plants in the same group. It remains to be seen, however, if in succeeding cuts the plants that still have to pole attain the same general level of yield.

If these observations prove to be correct it is apparent that, although rapid development is conducive to early poling, from the point of view of productivity it is not a disadvantage, as the same or bigger yields of fibre are obtained in a shorter time. Some revision of planting policy and cutting routine would be necessary however to take advantage of any cultural method leading to more rapid returns from the sisal plant.

The scapes of all poling plants on the observation plots have been cut off soon after they have appeared above the surrounding leaves. Four hundred and sixty plants have been treated in this way and during 1938 four of these plants have produced fruits and seed. This is the first occasion when fruiting of *A. sisalana* has occurred at Amani.

Observation plots of seedlings of *A. sisalana* were cut for the second time in July, 1938. One of the three recorded plots has had to be abandoned as it has been severely damaged by apes. Mr. G. W. Lock, Agricultural Officer (Sisal), undertook the harvesting of these plots and also of the comparative trial of *A. amaniensis* and *A. sisalana* with his staff from the Sisal Experiment Station, Ngomeni. His assistance in this

* Michotte, F. Agaves et Fourcroyas. Paris 1931, p. 162.

connection is gratefully acknowledged. The cutters, accustomed to handling Sisal, found the seedlings, with their spiny leaf margins, very difficult material to handle. A few of these seedlings again gave comparatively high yields of leaf but there is no doubt that the spiny leaf margins of all sisal seedlings rules them out as potential competitors of sisal. When the material at present being studied reaches the end of its cycle I do not propose to do any further work with seedlings of Sisal other than the testing of outstanding forms against Sisal at Ngomeni.

At the third cut of the comparative trial of *A. amaniensis* and *A. sisalana,* Sisal gave a significantly higher yield of leaf and unbrushed fibre than Blue Sisal. The mean yields of leaf and unbrushed fibre were, for Sisal, 285·9 kg. per plot and for Blue Sisal 211·2 kg. and 10·4 kg. respectively. The total yields of fibre and fresh leaf for the three cuts combined do not show any significant difference; the equivalent yields per acre of unbrushed fibre being at the rate of 6·6 tons of Blue Sisal and 6·5 tons for Sisal. The fibre from these plots has not been utilised for fibre investigations as the total output from small plots such as these is too small to be of practical value. Samples from the large block of *A. amaniensis* at the Sisal Experiment Station, Ngomeni, are now being examined periodically by the Sisal Section of the Linen Industry Research Association, Lambeg, with the co-operation of the spinners. As the results of their investigations are, for the time being at any rate, confidential, nothing more can be said at this juncture.

The interspecific hybrids *A. angustifolia* x *A. amaniensis* at the Sisal Experiment Station have maintained a very high rate of leaf production and some of the outstanding plants are now producing leaf over a metre long. This is by far the most interesting material that has been bred so far, promising to combine the high leaf number of *A. angustifolia* and some of the valuable qualities of the other parent. Owing to pressure of other work it has not been possible to examine the fibre qualities of this material but it should be possible in the near future. Samples of fibre, when available, will be sent to Lambeg for examination and report on their possibilities.

I intend, if possible, to repeat this cross early in 1939, using selected seedlings of *A. angustifolia* for the mother plants. This seedling material is the first inbred generation of this species. Three of the selected seedlings have produced over 700 leaves and one of these nearly 900 leaves during their life, compared with an average of about 235 for *A. sisalana* under similar conditions.

The seedlings obtained by selfing *A. angustifolia* are reaching the end of their cycle. The total leaf production of those plants that have poled shows a very wide range of variability, from

310 to 900 leaves per plant. Fifteen plants poled in 1937 and eleven of these were selfed during 1938. Only five produced fruits and the germination of the seed produced has been poor. Thirty-six more plants are now poling and it is intended to self as many as possible, in addition to making the crosses mentioned above. The isolation of fertile forms of this species that produce a large number of leaves should form a valuable basis for further breeding work.

In the last Annual Report (p. 26, para. 17), reference was made to the production of abortive flowers in this material. This was attributed to unfavourable weather conditions during development. However, this feature is again prominent this year on many of the earliest poles to appear. In each case it has been noted that the poles bearing abortive flowers have brownish-black lesions on the pole. Those free from this blemish appear to produce normal flowers but it is not possible to connect lesions and abortive flowers with any certainty as nearly all the plants with clean poles have yet to flower.

The hybrids *A. angustifolia* x *A. sisalana* have continued disappointing. The yields of leaf from the third cut are consistently low. Even the highest-yielding plants in this plot do not compare with *A. sisalana* on the adjacent plots.

A cross has been made between *A. amaniensis* and an unnamed species belonging to the Americanae group. There is a good set of fruits. Young seedling plants from the cross *A. angustifolia* x *A. lespinassei* have grown well in the nursery beds. Those obtained from *A. amaniensis* x *A. lespinassei* have developed much more slowly. Very slow development is also recorded for seedlings from the cross *A. angustifolia* x *A. cantala* and the two back crosses (*A. angustifolia* x *A. sisalana*) F1 x *A. angustifolia*.

Coffee.

The only work in progress with *C. arabica* at Amani is the study of inbred families of this species. Yields of the first inbred generations, some of which are bearing a fourth crop, have been low during the past season. The variability in yield within families is still very great. For one family of 31 plants the co-efficient of variability is 49·6 per cent. for the total yield of cherry. An inbred F_2 generation is bearing for the first time this year and two others should flower during the coming year.

An F_2 generation has been raised by selfing the sole surviving plant of an inbred F_1 of *C. arabica*. A feature of this family is the variation in the number of cotyledonary leaves.

Young plants of Robusta Coffee raised from controlled crosses between selected parents have made very good progress. In this material the influence of early treatment, prior to planting

in the field, on the subsequent development and uniformity is strikingly demonstrated. Material grown in pots before transplanting has given a much more uniform and vigorous stand of plants than the material transplanted from nursery beds. Amongst the latter there have been many more casualties in spite of the fact that they were carefully ball-planted.

The 1937-8 harvest of Robusta Coffee plots was not completed until after my departure from the Station and I have not yet been able to analyse the data collected. The 1938-9 crop is now being gathered and promises to exceed by a considerable margin that obtained last year. The cross *C. arabica* x *C. dybowskii* failed. One hundred and forty flowers were pollinated and only one fruit, containing one abortive seed, was collected. Seven good seeds were obtained from the cross *C. eugenioides* x *C. dybowskii* but unfortunately all these seeds were killed during germination by high temperature due to the vagaries of the incubator.

The F_1 hybrids of *C. arabica* x *C. canephora* have produced an increased quantity of fruits on open pollination this year. While most of the seeds are still abortive a fair number have been germinated successfully.

The Coffee from Embu, Kenya, referred to in the last Annual Report has been determined by the Royal Botanic Gardens, Kew as *C. eugenioides*. S. Moore. Older plants of this species growing at Amani have flowered during the year but have set very few fruits.

Recent additions to the collection of Coffees have been *C. ligustroides* S. Moore and *C. salvatrix* Philipson and Swynnerton, received from Southern Rhodesia through Mr. R. J. M. Swynnerton, Department of Agriculture Tanganyika Territory: *C. horsfieldiana* Miq. and *Coffea* sp. ("Kapakata coffee") from Dr. M. Hille Ris Lambers, Java; *C. congensis* Froehner from the Belgian Congo through the Coffee Research Station, Lyamungu.

The Inter-territorial Coffee Research Committee at their first meeting made certain specific recommendations having some bearing on the work of this section. The first, advocating an exploration of Abyssinia for wild Coffees as soon as political conditions permit, is of necessity still in abeyance. There are at the Scott Agricultural Laboratories seedlings raised from a wild coffee from the Geisha district of Abyssinia. They appear to be *C. arabica*. Cytological examination of root tip material from these seedlings reveals a somatic number of $2n = 44$ chromosome in common with other coffees of this species.

The second recommendation, that the Botanist and Geneticist at Amani should study the taxonomy of *Coffea*, is not one that can be undertaken lightly and would involve a great deal of

work in the European Herbaria, studying type specimens, as well as collecting African and other material for study.

Attention is drawn to the need for more work on Robusta Coffee. I have mentioned above that work with *C. arabica* is being restricted and that work with Robusta is to be extended as far as the resources thus freed permit. Visits to Robusta growing areas in Uganda and Bukoba are planned for 1939 in connection with this extension.

Minor crops.

Yield records have been maintained during the year on two plots of young *Aleurites montana* at Amani, and the observations on the sex of these plants have been continued. A revision of the figures published last year for sex has been made. Some of the plants recorded as purely male produced a few fruits; there is an appreciably lower proportion of purely male trees than was at first recorded. In recording yields only the weight and number of fresh fruits was obtained as the seed was required for propagation. A sample of the fruits was taken for the determination of the yield of dried seed. The weight of fresh seed is approximately 30 per cent. of the fresh fruit and dried seed 75 per cent. of the weight of fresh seed.

The mean yield for monoecious trees was 7·67 fruits per tree (·35 kg. fresh fruits) with a range of from 0-30 fruits (0-1·23 kg.). Purely female trees gave a mean yield of 86·04 fruits (3·71 kg.), the range being from 0-430 fruits (0-17·94 kg.). Plots are five years old from seed. The harvest period was March to June and flowering occurred during the period September to December. Two eight-year-old trees in the nursery, the parents of most of the Tung trees at Amani and Kwamkoro, produced a total of 58·5 kg. of fresh seed, during the year compared with a yield of 49·5 kg. in 1937.

Selection and breeding work with *Cinchona* is now on the Amani programme and a scheme for carrying out this work has been put forward. There is now a large area on Kwamkoro planted with *C. ledgeriana* raised from our own and selected Indian seed. There are also young plantations of *C. succirubra* and hybrid quinine (*C. ledgeriana* x *C. succirubra, F*$_1$). It is proposed to select from this material trees of outstandingly vigorous growth and a high alkaloid content. Seed of *C. josephiana,* a species that has given a very good bark analysis, has recently been received from Uganda.

The need for improving native food crops by selection and breeding has been stressed by Sir Frank Stockdale in his report on visit to East Africa in 1937. The director of this station has been given the task of surveying the field and drawing up a programme of the work required in collaboration with the Departments of Agriculture. Selection of sorghums resistant to attack

by the parasitic weed *Striga hermonthica* is an important problem in some areas and it is proposed that I should visit the Lake Province of Tanganyika early in 1939 to make a preliminary investigation of this problem.

SYSTEMATIC BOTANY.

My annual report for 1937 was written when on leave in England and belated acknowledgments are here made to all those who during that year contributed botanical material.

My leave terminated at the end of May. Up till then I continued working out the results of the Mafia Island survey at the Herbarium of the Royal Botanic Gardens, Kew, and at the British Museum. I also consulted the libraries of the Royal Geographical and Royal Empire Societies. As I could not specifically identify at the two former institutions about fifty of the plants collected on Mafia, I sent these to the Berlin Herbarium and, through the kindness of the Director, they were compared by the staff of that institution, when about thirty proved to be new to science.

My account of the vegetation and fauna of Mafia Island was completed as far as was then possible on the eve of my departure for East Africa and it has since been submitted to the Director. The account has yet to include analytical data from the Soil Chemist on the soils I collected and a note from Mr. Moreau on the birds obtained. I have also to describe for publication the new species of plants found.

I visited the Imperial Forestry Institute at Oxford in February and May and attended in May the various meetings of the 150th Anniversary of the foundation of the Linnean Society of London.

The demand for my " Swahili Dictionary of Plant Names " has been greater than the supply and it is now out of print. I am engaged on a second and revised edition to which many more names will be added. At the request of a number of departments and correspondents a section with English, botanical and Swahili names will be included.

I am steadily accumulating information on the uses of the indigenous plants by Africans and on the botanical equivalents of their native names. This information is card-indexed for ready accessibility. I have still to go systematically through the Herbarium to extract what native information is to be found on the specimens already filed. The card index of native names with botanical equivalents is proving to be extremely useful.

The Inter-territorial Coffee Research Committee recommended that the Amani Botanist should give attention to the taxonomy of the wild *Ficus* and *Albizzia* species potentially useful as coffee shade. If good and ample botanical material is submitted by all those interested the taxonomic study of the species should not involve lengthy investigations in European Herbaria because

the Tropical African members of the genus *Ficus* were monographed in 1917 and those of *Albizzia* in 1930.

A further recommendation of the Committee was that " In view of the present imperfect knowledge of the taxonomy of *Coffea* the Amani Botanist should attack the problem in collaboration with the Geneticist who was already dealing with the cytology of the genus ". An essential preliminary to this investigation is the detailed study of the type specimens at the principal European Herbaria by the two officers concerned. In the meantime the routine collection of all wild Coffees met with is being continued.

The work of revising for the Imperial Forestry Institute a " Check List of Trees and Shrubs of Tanganyika Territory " on which I and the late Mr. B. D. Burtt were engaged individually has been temporarily abandoned. It will be started again when the numerous collections of botanical specimens awaiting determination in the Herbarium have been dealt with.

The following paper was published during the year 1938:—

" The Botany and Agronomy of Kapok." East African Agricultural Journal, May, 1938, pp. 440-3.

The Herbarium.

Since January, 1937, 2,082 determinations have been made on specimens received for naming. Information and material were supplied to a wide range of institutions and workers in East Africa and other countries.

The unnamed German collections have now all been identified as far as possible and incorporated into the Herbarium. There is a considerable amount of named botanical material of my own and other people's collecting ready for distribution to various institutions as time permits.

In April, 1928, when I assumed charge of the Amani Herbarium it contained some 11,000 sheets of named specimens, the majority collected in the vicinity of the East Usambaras. Now there are over 34,800 named sheets of East African plants, obtained by exchanges with other institutions, through collectors in various government departments and from private individuals in East Africa. My own collections in East Africa are more than 5,800, usually made in triplicate or quadruplicate for the purpose of exchanges with other institutions after the first and second sets have been divided between the Royal Botanic Gardens, Kew, and Amani.

The available space in the Herbarium is now completely filled.

An African employed in the section during the past four years left last July for no apparent cause. He wrote a very good hand and was beginning to be of value in the routine work of the Herbarium as well as on surveys. His departure has

considerably delayed me in the work of the Herbarium and I have not yet been able to secure a suitable successor for the post.

Type Species.

A further 31 isotypes have been discovered, which, together with the following new species recently described, bring the total number of types known or recorded in the Amani Herbarium up to 343 isotypes:—

Carex Greenwayi Nelmes in Kew Bull. 1938, p. 244. Cyperaceae. Tanganyika Territory; Mt. Kilimanjaro, Bismarck Hill, 3,000 m. alt., 27/2/1934, *Greenway* 3840, type; Moshi to Marangu, 1,000 m. alt., 1/1/1915, *Grote* 5366.

Combretum Greenwayi Exell in Journ. Bot. 75: 165 (1937). Combretaceae. Tanganyika Territory; Usambara, S. Umba Steppe, Mshwanda, 430 m. alt., *Greenway* 2030, type.

Combretum Grotei Exell, lc. p. 166 (1937). Combretaceae. Tanganyika Territory; Kilimanjaro, Moshi, 2,500 m. alt., *Grote* 5071, type; Bismarck Hill, 3,000 m. alt., *Grote* 5076; Mhesa, Ruvu River, 500 m. alt., *Greenway* 2107.

Cordyla densiflora Milne Redhead in Fedde Repert. Sp. Nov. 41: 234 (1937). Papilionaceae. Tanganyika Territory; Dodoma District, Gulwe, 840 m. alt., 19/8/1930, *Greenway* 2405, type; Mpwapwa, 1,050 m. alt., *Hornby* 269.

Elephantopus scaber L. var. *hirsutus* Philipson in Journ. Bot. 76: 303 (1938). Compositae. Tanganyika Territory; Rungwe District, *Davies* 473, type.

Hibiscus Greenwayi E. G. Baker, lc. 75: 99 (1937). Malvaceae. Tanganyika Territory; N.W. Usambaras, S.W. Umba Steppe, Mnazi, 1,500 ft. alt., January, 1930, *Greenway* 2034, type; Kijango Magoma, *Braun* 2696.

Tephrosia iringae E. G. Baker, lc. 76: 21 (1938). Papilionaceae. Tanganyika Territory; Iringa Province, Misima Stock Farm, 5,500 ft. alt., 10/8/1933, *Greenway* 3524, type.

During 1937 and 1938 120 contributions of botanical material were received, representing a total of 6,241 specimens of which over 4,800 were received for identification.

Acknowledgment is made to the following:—

The Administration, Tanganyika; the Agricultural Departments, Tanganyika, Uganda, Kenya and Federated Malay States; the Berlin Botanic Gardens and Museum and the Royal Botanic Gardens, Kew; the Education Departments, Tanganyika and Uganda; the Forestry Departments, Tanganyika, Kenya and N. Rhodesia; the Game

Department, Kenya; the Medical Department, Laboratory and Research Division, Tanganyika; the Tsetse Research Department, Tanganyika; the Department of Veterinary Science and Animal Husbandry, Tanganyika; the Amani staff; and to numerous private individuals and others engaged in agricultural activities in East Africa.

Botanical material was exchanged with, and loaned to, various institutions and individuals in Europe, America, the Sudan, East and South Africa.

Field Work.

On my return from leave at the end of June I proceeded by car to Northern Rhodesia where I spent three months with the Ecologist, Mr. C. G. Trapnell, whom I accompanied on his agricultural and vegetational surveys of north-eastern Northern Rhodesia.

During this period Abercorn and Kasama Districts were visited, but most of our time was spent in the Mpika District. Some interesting relics of Evergreen Mist Forest that we discovered were studied and a number of tree species found that hitherto had not been recorded from Northern Rhodesia.

Near Lake Young, at Shiwa Ngandu, which was the temporary headquarters of the Ecological Survey, opportunity was taken to investigate the vegetation of some very interesting moorland-drainage peat bogs, these often containing considerable beds of peat, and a series of Evergreen Swamp Forest patches found in the neighbourhood.

In August after the visit to Shiwa Ngandu of the Royal Commission on Closer Union of the Rhodesias, I went on foot with Mr. Trapnell for three weeks across the Luangwa Valley to the Lundazi District and on to the Nyasaland border, thence back to Mpika. The different systems of native agriculture met with were studied, as far as the time permitted, in addition to the vegetation of the area traversed.

After the Luangwa Valley survey I went by way of Broken Hill to Ndola, I spent a week there with Mr. R. G. Miller, Assistant Conservator of Forests, seeing the work of the Forestry Section and its Herbarium and something of the vegetation of the Copper Belt. This does not seem to differ much from that in the north-eastern parts already traversed.

On my way back from Northern Rhodesia visits were paid to the District Commissioners of the Chinsali and Isoka Districts, to the Assistant Conservator of Forests, Mbeya, and to the Department of Veterinary Science and Animal Husbandry at Mpwapwa, Tanganyika, where I worked in the Pasture Research and Survey Herbarium and saw the pasture research work in progress there. From Mpwapwa I went to Morogoro

where a few days were spent at the headquarters of the Agricultural and Forestry Departments of Tanganyika. I finally arrived in Amani in the middle of October.

In the course of these visits I collected 416 numbers of botanical specimens in quadruplicate, nearly all in N. Rhodesia. These will be a most useful addition to the Herbarium as the flora of that area is not represented here.

Since my return further field work has been impossible and will be out of the question for at least a year. I am confronted with the task of naming over two thousand specimens which have been sent to Amani during my absence by various Government Departments and private individuals, most of whom are anxious to have the names of their plants as soon as possible.

When engaged on surveys or on leave I have no assistant to carry on the work of routine determinations or to act as a general " Enquiry Bureau ". Subjects raised range from weeds, lawn grasses, medicinal plants and those poisonous to cattle and man, to food plants and topics of general agricultural and horticultural interest. The activities of this section are therefore intermittent and not, as they properly should be, continous, and their progress, especially in a constructive sense, is grievously delayed.

P. J. GREENWAY,
Systematic Botanist.

ORNITHOLOGY.

Faunistic Work.

Collecting has been limited during the year to the Mafia archipelago and the adjacent mainland. I think that the avifauna of Mafia is now well known. An account of it is being prepared, and the opportunity is being taken to bring together also the available information, mostly unpublished, on the seabird colonies of the East African Coast.

On the basis of this account of the Mafia birds and the published lists for the Zanzibar Protectorate I have made a preliminary comparison of the avifaunae of Zanzibar, Pemba, Mafia and the coastal strip of the opposite mainland. The results do not accord with what might have been expected from the published conclusions regarding the geological history of the area, the chief point of which is that Pemba Island is much older than the others. This has led me to review the records of the mammology and herpetology, which, I find, are congruent with the avifaunal evidence. If no alternative interpretation of the geological evidence is forthcoming we are faced with a most peculiar problem of animal distribution. I hope

to be able, with suitable collaboration, to discuss the matter in a critical study of the vertebrate zoo-geography of the East African islands.

Little progress can be recorded with the study of the intra-continental distribution and differentiation of birds in relation to their degree of ecological isolation. As originally planned, it awaits ancillary studies of climate and vegetation. An intrinsic difficulty, the inconclusive state of the bird taxonomy, is not being reduced by time as I had hoped. Much of the published work on the subject is being shown to have no permanent value; the divergence between the " lumpers " and the " splitters " tends to increase rather than to diminish; and a third taxonomic way has been opened by the recently published " cline " concept of Huxley (Nature, Vol. 142, p. 219, 1938). Personally, I welcome this last as the best approach to a difficult subject, but its full use will require a vast amount of museum work and the accumulation of much larger series than we possess at present.

Climatic classification.

As recorded in my last annual report, the study mentioned in the preceding paragraph led me to investigate systems of climatic classification. Thanks to the assistance received from several sources I have been able to publish a fairly complete review, planned to be of general value for reference purposes as well as of local application. For East African ecology none of the published systems seems satisfactory: in general too great reliance has been placed on calculated single values, the bases of which are open to criticism. In East Africa it will probably be necessary to classify in terms of three criteria: temperature, length of influential rainfall period and amount of rainfall. A classification even on those lines, however, cannot fail to be invalidated locally by other factors, one of which is mist prevalence.

The problem of the reproductive rhythm.

The attack on this central problem of tropical biology has been continued, as before, by accumulating observational data in both semi-arid country and evergreen forest. Largely owing to the amount of time devoted to the subject by Mrs. Moreau at Amani and to her skill in the field, valuable additions to our data have been made in the course of the year; and for the first time we have an indication for certain evergreen forest birds that the local members of each species tend to begin laying almost simultaneously.

During local leave on the north side of Kilimanjaro in February special attention was given to the problem of the breeding season. Provisionally I conclude that in that locality the relationship between breeding activity and the annual cycle of

rainfall and temperature differs from any of the relationships described previously (*Proc. Zool. Soc. London,* 1936, pp. 631-653); and evidence is accumulating that within the comparatively uniform environment of evergreen forest and within the area of Kenya and Northern Tanganyika there are remarkable local variations in the breeding season. The Kilimanjaro data have been recorded in a paper that deals also with the bird-population of the moorland (*Rev. Zool. Bot. Afr.,* in press).

A fresh line of investigation has been started in collaboration with Professor W. Rowan of the University of Alberta, whose work on the histology of avian gonads is well known. Two specimens of each of three species are being collected every fifteen days for a year in order that the complete gonad and moult cycle may be examined.

Bird behaviour at the nest.

Practically nothing is on record of the amount of care that tropical birds give to their eggs and young, what food they bring to the nest and how often. In an earlier annual report I commented on the fact that comparatively low-paid Africans (costing less than 1½d. an hour) are very useful routine recorders. Thanks to a small grant from the Institute for the Study of Animal Behaviour I have been able to arrange for local employees to make long spells of observations on bird behaviour at the nest. Concentrating on the species of swifts and swallows that build at Amani, we have so far accumulated about three thousand hours of observations, from which, among other information, much can be learnt of the number of meals given to the young birds. Faeces are being collected and there is a good prospect of entomological co-operation, which will provide a body of evidence on the nature of the food brought.

The volume of the observations, much greater than that hitherto available for any group, tropical or temperate, will yield results of much theoretical interest. Ultimately it will be possible to make a statistical investigation, the first of its kind, into the extent to which such features of nest behaviour as the feeding rate are characteristic of, and peculiar to, the species, even within a closely allied group.

General.

The new book on the birds of Kenya and Uganda (Jackson and Sclater, 1938), has shown forcibly how much remains to be recorded of East African birds in life. Accordingly a selection of the field-notes accumulated incidentally by Mrs. Moreau and myself has been made for publication (*Ibis*, in press).

During the year I have been in frequent communication with workers at the British Museum, American Museum of Natural History, Coryndon Museum (Nairobi), Berlin Museum and Rothamsted Experimental Station, to all of whom my thanks

are due. With Dr. Van Someren I was able to make personal contact and discuss many matters of mutual interest. The British Museum continued to meet the expense of collecting.

The American Ornithologists' Union has recently been good enough to offer me the Corresponding Fellowship. A similar honour had been accorded to me by the Deutsche Ornithologische Gesellschaft.

The foregoing report should be read in the light of the fact that practically all official hours are occupied by my routine administrative duties.

Publications.

Descriptions of the new forms *Erythropygia barbata greenwayi* and *Artisornis winifredae*. Bull. B.O.C., Vol. 57, p. 64, p. 139, 1938.

The avifauna of the mountains along the Rift Valley in north central Tanganyika Territory (Mbulu District). Part II. *Ibis*, Ser. 14, Vol. 2, pp. 1-32, 1938.

Bird migration over the north-western part of the Indian Ocean, the Red Sea and the Mediterranean. *Proc. Zool. Soc. London*, Vol. 108 (A), pp. 1-26, 1938.

A contribution to the biology of the *Musophagiformes*, the so-called Plantain-eaters. *Ibis*, Ser. 14, Vol. 2, 639-671, 1938.

Climatic classification from the standpoint of East African biology. *J. Ecol.*, Vol. 26, pp. 467-496, 1938.

The comparative breeding biology of two *Euplectes* spp. in Usambara. *J. Anim. Ecol.*, Vol. 7, pp. 314-327, 1938. (In collaboration with W. M. Moreau.)

R. E. MOREAU.

PLANTATION WORK.

The Superintendent of Plantations proceeded on vacation leave on January 21st and returned to duty on October 28th. Commander H. V. Low, a local planter, was appointed Acting Superintendent of Plantations for the period January 18th to June 26th.

Mr. C. B. Gibbins, Agricultural Assistant, Coffee Research and Experimental Station, Lyamungu, was appointed Assistant Superintendent of Plantations and assumed duty on March 28th. The supervision of the planting and maintenance of crops at Kwamkoro, made more difficult by labour shortage, occupied much of the Assistant Superintendent's time after Commander Low's departure. During December the Assistant Superintendent spent two weeks in Zanzibar on experimental propagation and grafting in connection with investigations into "Sudden Death" of clove trees.

Amani.

The Amani plantations have been periodically cleaned and a considerable amount of nursery work done. Cinchona seedlings, coffee, derris and other economic plants were raised in quantity to supply the needs of the scientific officers, while a considerable number of plants and seeds of various trees and economic crops were distributed. The supervision of the 10-acre plot in the Kizugu valley below Sigi, was taken over by the Superintendent on his return from leave.

Aleurites montana.—The two original trees in the nursery fruited heavily, giving a combined yield of 129 lbs. of fresh seed. Other young trees in the plantation plots also yielded fair crops.

Aleurites Fordii.—These trees have again produced a few fruits.

Tuba Root. Derris elliptica.—With the exception of plants for Kwamkoro and the Biochemist's experiments at Amani no derris has been propagated. A number of successful experiments on grafting with different Derris species were also carried out for the Biochemist.

Blue Sisal.—Approximately 570,000 bulbils of *Agave amaniensis* were collected for distribution during the year. As a precaution against the spread of Sisal Weevil it was decided to fumigate all bulbils intended for destinations outside the Tanga Province of Tanganyika. This was carried out at the Sisal Experimental Station, Mlingano. Unfortunately a large proportion were damaged in the process and were lost. A further 250,000 to 300,000 bulbils should be available for distribution during 1939.

Agave collection.—A plot for the collection of Agave species and varieties was prepared and planted at Sigi.

Cinchona.—One acre was planted with *Cinchona ledgeriana* raised from Indian seed. Eight thousand plants from this source are still in nursery beds and will be used to extend the Amani area. Any balance, together with some 2,000 of *C. ledgeriana* raised from Amani seed, will be planted at Kwamkoro to complete the required 100 acres.

Mundulea Bark. Mundulea sericea (=*suberosa*).—The plots of this species near Sigi are growing well.

Coffee spp.—The chief work on coffee has been raising seedlings for the Geneticist in connection with his coffee breeding work, and routine cleaning of the coffee plots. Plants have also been raised for the Entomologist and Physiologist.

Tephrosia spp.—Seeds of 20 *Tephrosia* species and varieties were introduced during the year, 10 of these being kindly supplied by the Director, Royal Botanic Gardens, Kew. Seventeen are being multiplied in the nursery; 3 species did not germinate.

Native food crops.—The yams (*Dioscorea* spp.) in the collection are being multiplied. Plots have been planted at Amani and also at Kizugu; all are growing well.

Seven new varieties of Sweet Potatoes (*Ipomoea batatas*) have been introduced and are being propagated, together with the varieties already established.

Seeds of *Coix Lachryma-Jobi* (Job's Tears) were introduced for trial from Ceylon where it is used as a native food crop. Fourteen varieties of Pigeon Peas (*Cajanus indicus*) have been introduced and planted in the Kizugu plot.

Seeds of a number of other native food crops have been obtained for planting during the next rainy season. The following is a list of food crops introduced during 1938 which are being multiplied for distribution:—

Soya Beans (*Glycine hispida*), 25 varieties; Job's Tears (*Coix Lachryma-Jobi*); Pawpaws (*Carica Papaya*), 6 varieties; Pigeon Peas (*Cajanus indicus*), 14 varieties; Sweet Potatoes (*Ipomoea batatas*), 6 varieties. Plants introduced prior to 1938 and still being grown for distribution:—Yams (*Dioscorea* spp.), 21 varieties; Sweet Potatoes (*Ipomoea batatas*), 5 varieties; Coco Yams (*Colocasia & Xanthosomas* varieties), 7 varieties.

Plant and Seed Importations and Distributions.

Importations.—Sixty-three consignments consisting of 206 packets of seeds and 131 plants and cuttings.

Distributions.—569,000 sisal bulbils; 299 packets of seeds; 471 plants; 771 Sugar cane cuttings; 115 lbs. Ginger rhizomes; 106 lbs. Tung Oil seed; 23 oz. Cinchona seed; 1 cwt. Ramie roots and 124 miscellaneous tubers and cuttings.

KWAMKORO.

Tung Oil (*Aleurites montana*).—The 108 acres established have continued to make good growth, and the few casualties have been replanted. A number of trees have flowered this year and the sex of each flowering tree has been recorded so that any excess of unprofitable male trees may be corrected. Ring weeding was continued.

Tuba Root (*Derris elliptica*).—A further 25,000 derris plants have been planted. Of these 60 per cent. were rooted in the Amani nursery and planted in bamboo pots. The remaining 40 per cent. were rooted near their permanent site and then transplanted. The latter method has not been as successful as the former, as the plants are much weaker and make slower growth with a correspondingly higher percentage of losses. It has the advantage however of being much cheaper, especially where sandy soils, suitable for rooting cuttings, are adjacent to the plantation site. The 1936 and 1937 plantings continue to flourish and are in a particularly healthy condition. The 1935 plantings were harvested. Approximately 600 lbs. of fine

dried root was obtained and despatched to London and sold at Sh.1/- per lb. The amount of dried root per plant obtained was small, owing to the continual removal of cuttings from the plants to extend the Kwamkoro plantings and for distribution to planters. During this harvesting period 27,000 cuttings were obtained from the plot; 14,000 were planted at Kwamkoro and 13,000 sold to planters.

Cinchona.—The 26,000 *C. ledgeriana* plants, mentioned in the last report as raised from selected seed purchased in India, were planted in an old Arabica coffee plantation. The old coffee trees were removed but a certain amount of the *Grevillea* shade retained. Eight thousand five hundred plants of hybrids were also interplanted in this area between the coffee. Closer planting than formerly has been adopted.

The hybrid quinine interplanted between the old coffee in 1937 has made good progress although buck have done much damage in places. The earlier plantings of *C. succirubra* however do not show the same promise, while the *C. ledgeriana* and hybrids planted entirely without shade have not made the progress that might have been expected under shade.

Coffea robusta.—The plot to be intensively cultivated was planted during the year. A large quantity of manure from the cattle sheds adjoining the plot has been accumulated for application during the next few months.

The extensive area of *Coffea robusta* has suffered more than any other crop from the labour shortage. With the present inadequate labour force it has been found almost impossible to cope with the weed growth. Some of the smaller plantations and some parts of the larger ones have withstood the adverse conditions. Two and a half tons of clean coffee have been harvested.

Coffea arabica.—The plot of *Coffea arabica* grafted on *C. robusta* stocks is extremely disappointing. Attacks by White Coffee Borer and by leaf-miners, together with a large percentage of losses during the dry season, have seriously affected the value of this experiment. Small patches only appear to be worth further attention, while the major portion of the area could be used to better advantage under another crop.

No work has been done on the old *Coffea arabica* plantation.

Ginger (*Zinziber officinalis*).—One hundred and fifteen lbs. of ginger rhizomes from a small plot grown in the old coffee nursery were distributed and a small area has been replanted.

Animals.—Sickness, mainly trypanosomiasis, among the cattle has been more prevalent than previously, especially in the early part of the year. A native Veterinary Assistant capable of diagnosing infection and injecting the animals has been posted to Kwamkoro by the Veterinary Department.

Periodical examination of blood slides from all animals now enables infection to be diagnosed at an early stage.

Rainfall.—Rainfall in 1938 was 90·15 inches distributed over 154 days.

QUARANTINE.

Twelve varieties of Sugar cane, 62 varieties of Cassava, 15 *Agave* species, 2 Coffea species, 27 *Aloe* species, 2 *Furcraea* species, a consignment of *Agave sisalana* seedlings from Germany and a collection of ornamental plants were received into quarantine during the year.

Sugar cane varieties imported were as follows:—C O 419, C O 426, C O 432, C O 434, F.C.915, P.R.803, P.R.809, P.O.J.2961, M.171/30, M.72/31, M.73/31, M.134/32.

VISITORS.

During the year the station was visited by Dr. H. A. Tempany, C.B.E., Assistant Agricultural Adviser to the Secretary of State for the Colonies, and Dr. A. J. R. O'Brien, C.M.G., M.C., Medical Adviser to the Secretary of State for the Colonies.

East African visitors include:—

L. A. W. Vickers-Haviland, Administration, T.T.; R. B. Allnutt, Dept. Agric., T.T.; H. R. Herring, Forestry Dept., T.T.; W. Cartmell, D.C.M., Vety. Dept., T.T.; J. B. Brown, Acting Accountant-General, T.T.; A. J. Wakefield, Director of Agriculture, T.T.; H. E. Harbour, Vety. Dept., T.T.; A. Mann and A. Phipps, Sisal Products (E.A.) Ltd., Kenya; G. A. Tait, T.T.; A. Ward, Southern Rhodesia; Dr. D. B. Wilson, Medical Dept., T.T.; G. W. Lock, Dept. Agric., T.T.; W. J. Poppleton, Kenya; Dr. R. R. Scott, Director of Medical Services, T.T.; Dr. G. R. C. Wilson, Medical Dept., T.T.; Major L. A. Notcutt, T.T.; H. Gillman and W. V. Harris, Dept. Agric., T.T.; H. P. Smart, Dept. Agric., T.T.; R. Johns, Dept. Agric., Zanzibar; Ch. Hedde, T.T.; The Bishop of Zanzibar; A. Thomas, T.T.; J. H. B. Murphy, Administration, Kenya; Major von Brandis, T.T.; Dr. E. Weigt, T.T.; Capt. J. L. Berne, O.B.E., Administration, T.T.; Major H. E. Ward, Kenya; J. D. Jameson, Dept. Agric., Uganda; W. A. Grinsted and J. P. Henderson, B.E.A.M.S.; R. W. Miller, Director of Agriculture, Zanzibar; Dr. A. M. Campbell, Dept. Agric., Zanzibar; Lt.-Col. the Hon. M. T. Boscawen, T.T.; W. J. Bonavia, Administration, T.T.; C. Gillman, C.B.E., Water Consultant, T.T.; A. J. Kerr, Dept. Agric., Uganda; Mrs. Tothill, Uganda; F. B. Notley, Dept. Agric., T.T.; P. R. O. Bally, Coryndon Museum, Nairobi.

Overseas visitors include:—

Dr. Conrad Roediger, Berlin; Dr. Alan Mozley, London; H. M. Mansfield, Liverpool; G. O. Hoppé, London; Dr. H. Barat, French Colonial Service; Dr. G. M. Walcott, Rio de

Janeiro; Dr. B. S. Platt and Miss F. Owen, Medical Research Council, London; A. O. D. Mogg, Pretoria; Dr. R. Orth, Heidelberg; Prof. Dr. W. Gleg, Frankfurt a.M.; Dr. H. Lettau, Leipzig; Col. Charles Ponsonby, London; Alfons Bürger, Münich; Lady Falmouth; Dr. M. Hille Ris Lambers, Proefstation Midden-en Oost-Java, Malang; Dr. R. Van der Veen, Proefst. Djember, Java.

Dr. Walter Carter's visit in connection with his work on mealy-bugs of pineapple, mentioned in the last annual report, extended into February, 1938.

APPENDIX A.

Financial statement for the year ended 31st December, 1938.* Revenue.

	£
H.M. (Imperial) Treasury	6,000
Contribution Tanganyika Territory	7,592
Contribution Uganda	2,278
Contribution Kenya	2,152
Contribution Zanzibar	1,200
Contribution Northern Rhodesia	300
Contribution Nyasaland	300
	19,822
Local sales	437
	£20,259

Maintenance Expenditure.

	£
Personal Emoluments	11,793
Passages	585
Pensions Contributions	1,956
Laboratories	895
Library	—†
Publications	92
Office, Telephones and Contingencies	204
Materials	879
Freight and Transport	405
Travelling	837
Labour	1,533
	£19,179

	£
Amount included in 1938 estimates for special transfer to reserve to meet future commitments on incremental appointments, the revenue being on a five years flat-rate basis	362

* At the time this statement was compiled the final accounts for the year had not been received from the Accountant-General, Dar es Salaam. No important alteration is, however, expected.

† The maintenance of the Library was borne by the Carnegie Trust Fund.

Capital Expenditure.

	£
Reconditioning quarters	468
Electrical reconstruction	40
Reconditioning electric generator	14
	£522

Summary.

	£	£
Recurrent Revenue	20,259	
Reserve on 31st December, 1937	3,471	
		23,730
Maintenance Expenditure	19,179	
Capital Expenditure	522	
		19,701
Reserve on 31st December, 1938		4,029
Capital expenditure authorised out of Reserve ...	1,056	
Required for incremental (Maintenance) commitments	362	
		1,418
		2,611

APPENDIX B.

I. List of publications distributed up to 31st December, 1938, by the East African Agricultural Research Station.

Memoirs.

1. Records of butterfly migration in East Africa. C. B. Williams, *East Afr. Uganda Nat. Hist. Soc.*, No. 35, pp. 1-16, 1929.
2. Collected records relating to insect migration, First and Second Series. C. B. Williams, *Trans. Ent. Soc. London*, Vol. 77, pp. 79-91, 1928; Vol. 79, pp. 139-170, 1930.
3. Locust-hoppers and birds in East Africa. R. E. Moreau, *Bull. Ent. Res.*, Vol. 21, pp. 141-145, 1930.
4. The bird-population of a settled valley in the West Usambaras, Tanganyika Territory. R. E. Moreau, *J. Ecol.*, Vol. 19, pp. 64-74, 1931.
5. The filtration of the virus of streak disease of maize. H. H. Storey, *Ann, Appl. Biol.*, Vol. 19, pp. 1-5, 1932.
6. The estimation of carbon in plant tissues. R. R. Worsley and F. J. Nutman, *Ann. Bot.*, Vol. 45, pp. 693-707, 1931.
7. A bark disease of coffee in East Africa. H. H. Storey, *Ann. Appl. Biol.*, Vol. 19, pp. 173-184, 1932.
8. The Vegetation of Mpwapwa, Tanganyika Territory. P. J. Greenway, *J. Ecol.*, Vol. 21, pp. 28-43, 1933.
9. Pleistocene climatic changes and the distribution of life in East Africa. R. E. Moreau, *J. Ecol.*, Vol. 21, pp. 415-435, 1933.
10. On the food of the Red-billed Oxpecker. R. E. Moreau, *Bull. Ent. Res.*, Vol. 24, pp. 325-335, 1933.

11. The inheritance by an insect vector of the ability to transmit a plant virus. H. H. Storey, *Proc. Roy. Soc. London, Ser. B.*, Vol. 112, pp. 45-60, 1932.
12. A sulphur-deficiency disease of the tea bush. H. H. Storey and R. Leach, *Ann. Appl. Biol.*, Vol. 20, pp. 23-56, 1933.
13. A note on the distribution of *Gypohierax angolensis* (Gmel.), the Vulturine Fish-eagle. R. E. Moreau, *J. Animal Ecol.*, Vol. 2, pp. 179-183, 1933.
14. Observations on the Desert Locust in East Africa from July, 1928, to April, 1929. C. B. Williams, *Ann. Appl. Biol.*, Vol. 20, pp. 463-497, 1933.
15. A contribution to tropical African bird-ecology. R. E. Moreau, *J. Animal Ecol.*, Vol. 3, pp. 41-69, 1934.
16. A chemical survey of the waters of Mount Meru, Tanganyika Territory, especially with regard to their qualities for irrigation. D. Sturdy, W. E. Calton and G. Milne, *J. East Afr. Uganda Nat. Hist. Soc.*, No. 45, pp. 1-38, 1933.
17. Investigations of the mechanism of the transmission of plant viruses. H. H. Storey, *Proc. Roy, Soc. London, Ser. B.*, Vol. 113, pp. 463-485, 1933.
18. Root-systems of *Coffea arabica*, Parts I and II. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. I, pp. 271-284, 285-296, 1933.
19. Taxonomic and field notes on some birds of North-East Tanganyika Territory. W. L. Sclater and R. E. Moreau, *Ibis*, Ser. 13, Vol. 2, pp. 487-522, 656-683, 1932; Ser. 13, Vol. 3, pp. 1-33, 187-219, 399-440, 1933.
20. Some East African essential oils. R. R. Worsley, *Bull. Imp. Inst.*, Vol. 32, pp. 253-270, 1934.
21. The insecticidal properties of some East African plants. I. R. R. *Worsley, Ann. App. Biol.*, Vol. 21, pp. 649-669, 1934.
22. Root-systems of *Coffea arabica*, Part III. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. 2, pp. 293-392, 1934.
23. The photodynamic action of methylene blue on the virus of a plant disease. H. H. Storey, *Ann. Appl. Biol.*, Vol. 21, pp. 588-589, 1934.
24. Some eco-climatic data for closed evergreen forest in tropical Africa. R. E. Moreau, *J. Linn. Soc. Zool.*, Vol. 39, pp. 285-293, 1935.
25. A synecological study of the Usambara Mountains, Tanganyika Territory, with particular reference to birds. R. E. Moreau, *J. Ecol.*, Vol. 23, pp. 1-43, 1935.
26. Cinchona in Amani. R. R. Worsley, *Bull. Imp. Inst.*, Vol. 33, pp. 14-31, 1935.
27. Some suggested units of classification and mapping, particularly for East African soils. G. Milne, *Soil Research*, Vol. 4, pp. 183-198, 1935.
28. Studies on the ecology of coffee plantations in East Africa, I: The climate and eco-climates of coffee plantations. T. W. Kirkpatrick. Published by the Crown Agents for the Colonies, London, 1935.
29. A short geographical account of the soils of East Africa. G. Milne, in collaboration with East African soil chemists. *Trans. 3rd Internat. Cong. Soil Sci.*, Vol. I, pp. 270-274, 1935.
30. Composite units for the mapping of complex soil associations. G. Milne, *ibid.*, pp. 345-347, 1935.
31. A provisional soil map of East Africa. G. Milne, in collaboration with East African soil chemists. *Ibid.*, pp. 266-270, 1935.
32. A critical analysis of the distribution of birds in a tropical African area. R. E. Moreau, *J. Animal Ecol.*, Vol. 4, pp. 167-191, 1935.
33. A contribution to the ornithology of Kilimanjaro and Mt. Meru. R. E. Moreau, *Proc. Zool. Soc. London*, 1935, pp. 843-891.

34. The insecticidal properties of some East African plants: II. *Mundulea suberosa* Bentham. Pt. I. Insecticidal properties. R. R. Worsley, *Ann. Appl. Biol.*, Vol. 23, pp. 311-328, 1936.
35. Mundulea fish poison. P. J. Greenway, *Bull,. Misc. Inf. Kew*, pp. 1-8, 1936.
36. A provisional soil map of East Africa (Kenya, Uganda, Tanganyika and Zanzibar) with explanatory memoir. G. Milne, in collaboration with East African soil chemists. Published by the Crown Agents for the Colonies, London, 1936.
37. Breeding seasons of birds in East African evergreen forests. R. E. Moreau, *Proc. Zool. Soc. London*, 1936, pp. 631-653.
38. Chromosome behaviour in relation to genetics of Agave: I. Seven species of fibre Agave. L. R. Doughty, *J. Genet.*, Vol. 33, pp. 197-205, 1936.
39. Rotenone I: The determination of rotenone. R. R. Worsley, *J. Soc. Chem. Ind.*, Vol. 55, pp. 349-357^{T}, 1936.
40. The breeding biology of certain East African hornbills. R. E. Moreau, *J. East. Afr. Uganda Nat. Hist. Soc.*, Vol. 13, pp. 1-28, 1936.
41. Rotenone II: Evaluation of plants containing rotenone R. R. Worsley, *J. Soc. Chem. Ind.*, Vol. 6, pp. 15-23^{T}, 1937.
42. An inexpensive recording manometer. F. J. Nutman, *Ann. Bot.* (N.S.), Vol. 1, pp. 205-6, 1937
43. Agave fibres. Parts I and II. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. 5, pp. 75-92, 93-111, 1937.
44. Colour vision in the triungulin larva of a Strepsipteron (*Corioxenos antestiae* Blair). T. W. Kirkpatrick, *Proc. R. Ent. Soc. London*, Vol. 12 (A), pp. 40-44, 1937.
45. A new virus disease of maize transmitted by *Cicadulina* spp. H. H. Storey, *Ann, Appl. Biol.*, Vol. 24, pp. 87-94, 1937.
46. Note on soil conditions and two East African vegetation types. G. Milne, *J. Ecol.*, Vol. 25, pp. 254-258, 1937.
47. The evaluation of derris and mundulea. R. R. Worsley, *J. Soc. Shem. Ind.*, Vol. 57, pp. 175-176^{T}, 1937.
48. Insecticidal properties of some East African plants: III. *Mundulea suberosa* Benth. Part 2. Chemical constituents. Part 3. Variability of samples. R. R. Worsley, *Ann. Appl. Biol.*, Vol. 24, pp. 651-664, 1937.
49. Essays in applied pedology. I. Soil type and soil management in relation to plantation agriculture in East Usambara. G. Milne, *East. Afr. Agr. J.*, Vol. 3, pp. 1-14, 1937.
50. Studies of the physiology of *Coffea arabica*: I. Photosynthesis of coffee leaves under natural conditions. F. J. Nutman, *Ann. Bot.* (N.S.), Vol. 1, pp. 353-368, 1937.
51. Migrant birds in Tanganyika Territory. R. E. Moreau, *Tanganyika Notes Rec.*, No. 4, pp. 1-34, 1937.
52. Comparative breeding biology of the African hornbills (Bucerotidae). R. E. Moreau, *Proc. Zool, Soc. London*, 1937, pp. 331-346.
53. Biochemical studies of *Derris* and *Mundulea*. I. The histology of rotenone in *Derris elliptica*. R. R. Worsley and F. J. Nutman, *Ann. App. Biol.*, Vol. 24, pp. 696-702, 1937.
54. Defaecation by a Jassid species. H. H. Storey and R. F. W. Nichols, *Proc. R. Ent. Soc. London*, Vol. 12(A), pp. 149-150, 1937.
55. Studies of the Physiology of *Coffea arabica*. II. Stomatal movements in relation to photosynthesis under natural conditions. F. J. Nutman, *Ann. Bot.* (N.S.), Vol. 1, pp. 681-693, 1937.
56. Studies on the ecology of coffee plantations in East Africa. II. The autecology of *Antestia* spp. (Pentatomidae) with a particular account of a Strepsipterous parasite. T. W. Kirkpatrick, *Trans. R. Ent. Soc. London*, Vol. 86 (14), pp. 247-343, 1937.

57. Experimental breeding of fibre agaves in East Africa. L. R. Doughty, *East Afr. Agr. J.*, Vol. 3, pp. 222-228 (1937), pp. 268-278 (1938).
58. The avifauna of the mountains along the Rift Valley in north central Tanganyika Territory (Mbulu District). R. E. Moreau. Parts I and II. *Ibis*, Ser. 14, Vol. 1, pp. 760-786, 1937; Vol. 2, pp. 1-32, 1938.
59. Virus diseases of East African plants. VII. A field experiment in the transmission of cassava mosaic. H. H. Storey and R. F. W. Nichols, *E. Afr. Agr. J.*, Vol. 3, pp. 446-449, 1938.
60. Bird migration over the north-western part of the Indian Ocean, the Red Sea and the Mediterranean. R. E. Moreau, *Proc. Zool. Soc. London*, Vol. 108(A), pp. 1-26, 1938.
61. The internal anatomy of *Corioxenos antestiae* Blair (Strepsiptera). B. Cooper, *Proc. R. Ent. Soc. London, Ser. A*, Vol. 13, pp. 31-54, 1938.
62. Investigations of the mechanism of the transmission of plant viruses by insect vectors. II. The part played by puncture in transmission. H. H. Storey, *Proc. Roy. Soc. London, Ser. B*, Vol. 125, pp. 455-477, 1938.

Reprints.

1 and 2. Biological and other notes on some East African birds. R. E. Moreau and W. M. Moreau. Parts I and II. *Ibis*, Ser. 14, Vol. 1, pp. 152-174, 321-343, 1937.
3. Normal erosion as a factor in soil profile development. G. Milne, *Nature*, Vol. 136, p. 548, 1936.
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II.—Publications not available in time for distribution in 1938. Memoirs.

63. A contribution to the biology of the Musophagiformes, the so-called Plantain-eaters. R. E. Moreau, *Ibis*, Ser. 14, Vol. 2, pp. 639-671, 1938.
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66. Studies of the mosaic diseases of cassava. H. H. Storey and R. F. W. Nichols, *Ann. Appl. Biol.*, Vol. 25, pp. 790-806, 1938.

The root-system of *Agave sisalana* in certain East African soils. J. Glover, *Emp. J. Exper. Agr.*, in press.

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